Palm Cockatoo EEP Husbandry Manual

Adapted by Cathy King and Roger Wilkinson from the SSP Manual with the kind permission of Mike Taylor

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Palm Cockatoo (Probosciger aterrimus) - North American Captive Population History.

In 1983, 100 Palm Cockatoos (*Probosciger aterrimus*) were confiscated by the United States Fish and Wildlife Service (USFWS). Ten zoological institutions received ten birds each to hold until the legalities of the confiscation case were completed. After the case was resolved, each holding institution was allowed to keep two pairs. The remaining birds were auctioned off to private individuals by the USFWS. Those receiving Palm Cockatoos were required to join the newly formed Palm Cockatoo Consortium. Ron Young of the Greater Baton Rouge Zoo became the chairman and was approved, in 1985, by the Wildlife Conservation Management Committee (WCMC) of the American Zoo and Aquarium Association (AZA) to develop a North American regional studbook. Mr. Young petitioned for and was approved by the WCMC, in 1988, to convert the consortium into the Palm Cockatoo Species Survival Plan (SSP). In 1990, Mr. Young transferred the SSP Coordinator and Studbook Keeper duties to Mike Taylor of White Oak Conservation Center with the approval of the WCMC. In October 1992, the Palm Cockatoo Management Group developed the first Master Plan for the SSP.

Palm Cockatoo (Probosciger aterrimus) - European Captive Population History.

A Joint Management of Species Programme (JMSP) for Palm Cockatoo was first proposed in 1985 through the Parrot Working Group of the Federation of Zoos of Great Britain and Northern Ireland (now the British and Irish Association of Zoos and Aquaria, BIAZA). At that time wild caught Palm Cockatoos were being traded internationally and although not listed in the Red Data Book were considered to be potentially threatened in the wild. For this reason and their striking appearance and clear ambassadorial value they became the charismatic symbol of the World Parrot Trust. An unofficial studbook was developed by Roger Wilkinson (then Curator of Birds at Chester Zoo) that was initially restricted to a small set of UK zoos but later expanded to include private participants. The first Palm Cockatoo Regional Studbook for the British Isles was published in 1989 and included a historical listing of 49 birds. The 36 living birds included 15 distributed between seven participating zoos and bird gardens and 21 in three private collections. The bulk of these birds were wild caught with only one captive bred.

A second British Isles Regional Studbook was published in 1991 and following the approval of an EEP (European Endangered Species Programme) for Palm Cockatoos with Roger Wilkinson as Species Co-ordinator/ Studbook Keeper the first European EEP studbook was published in 1993. At that time a number of private participants decided against joining the EEP programme. As at 31 December 1992 a total of 83 living Palm Cockatoos were registered with the EEP. These were held at 17 zoos and two in private collections. Subsequent editions of the EEP Palm Cockatoo Studbook have been produced annually with the most recent (13th EEP edition, data current to 31 Dec 2004) published in March 2005. For 2003 and 2004 Dave Brunger took over as Studbook Keeper with

Roger Wilkinson remaining as Species Co-ordinator. In summer 2005 the co-ordination of the EEP was handed over from Chester Zoo to Zoo Beauval with Cathy Pelsy as Species Co-ordinator/ Studbook Keeper.

The EEP population at 31 December 2004 was then76 birds (42 males, 32 females, 2 unknown sex) held at 26 collections. This indicated fewer birds distributed over a larger number of collections.

Throughout the whole period there has been a sex imbalance in the EEP population with more males than females. Growth in the EEP Palm Cockatoo population has largely been through new collections joining the programme. New birds have also been added to the programme through customs confiscations donated or loaned to zoos. Although a number of collections have been successful in breeding Palm Cockatoos this has often been inconsistent and for the population as a whole mortality has exceeded natality every year until 2004 when six of seven chicks hatched were successfully reared and only two adult deaths recorded.

The Development of the Husbandry Manual

Development of the SSP Palm Cockatoo Husbandry Manual began with a meeting in April 1994, and the first edition was published in 1996 by White Oaks Conservation Canter, under editorship of Mike Taylor, Palm Cockatoo SSP Coordinator. The results of that first effort evolved into the second (1998) edition under the continued editorship of Mike Taylor. As this manual contains so much good information and is organized in such a logical manner it seemed a waste of time to begin again from scratch with development of the EEP manual. Fortunately for Europe, Mike Taylor was gracious enough to give us free reign to take over the US manual and adapt it to European culture and experiences. That is what we have done here, and while the original author names are still on the chapters where applicable, passages not relevant to Europe have been removed and other sections added. Therefore it is impossible to blame any one person for what you might find in the manual!

A European Palm Cockatoo Management Survey was sent out to all Palm Cockatoo EEP participants and to Umgeni Bird Park in South Africa. Seventeen persons, including respondents from Almaty Zoo, Zoo Parc de Beauval , Private 11, Umgeni Bird Park, Chester Zoo, Paradise Park, Liberec, Tisch Family Zoo, Jeruselum, Al Aziz Gardens, Novosibirisk Zoo, Rotterdam Zoo, Loro Parque, Stuttgart Zoo, Wroclaw Zoo, Zoo Wuppertal, Vienna Zoo, and Visburg. Responses from this questionnairre were incorporated into the guidelines when it was felt that they added more than what was already written in the AZA guidelines.

Acknowledgments

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Bill Aragon, Rio Grande Zoo; Rochell Berman, White Oak Conservation Center; Matthew W. Bond, Avicultural Breeding and Research Center; Sherry Branch, Sea World of Florida; Sue Crissey, Brookfield Zoo; Diane Downs, Avicultural Breeding and Research Center; Elizabeth Ferguson, White Oak Conservation Center; Andrea Fidgett, North of England Zoological Society; Susan

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We gratefully thank Mike Taylor for allowing us to use this extremely useful document and giving us the freedom to adapt and change it to fit the EEP goals. This serves as a wonderful example of cooperation between the North American and European regions, and is much appreciated!

We also thank participants in the European Palm Cockatoo Management Questionnaire for their responses, and to M. Rheinschmidt and M. Penning for commenting on the AZA version of the manual.

Cathy King
Roger Wilkinson

Chapter 1
General Characteristics and Natural History
by Mike Taylor from the White Oak Conservation Center

In an attempt to present the information in this manual in a more organized and more easily accessible format, the information for this section has been extracted from the following chapters;

Housing by Sherry Branch and Ron Young
Behavior by Pat Rider and Mike Taylor
Reproduction by Trent Swigert
Adult Nutrition by Carla Marquardt and Dr. Kimberley Howard
(Note: For the EEP manual this original chapter has been replaced)
Adult Medical Care by Dr. Bond, Diane Downs and Sharon Wolf

1.1 Physical Characteristics

Palm Cockatoos, while similar to other cockatoos in some ways, have unique physical characteristics. They are considered by many to be the largest cockatoos (Lint, 1976; Low, 1980; Forshaw 1981), ranging from 49 cm to 68 cm in total length, measured from the top of the head to the tip of the tail. The Palm Cockatoo is a long, lean bird, and is relatively lightweight for its size. There is a wide range of size among individual birds and across subspecies. At the Avicultural Breeding and Research Center (ABRC), females have ranged in mass from 503 to 950 g and the males from 545 to 1092 g. (Schubot and Clubb, 1992)

Perhaps the most distinctive feature of the Palm Cockatoo is the extensive red, naked facial "cheek" patch. The tone of the facial patch is not constant, and may range from brilliant crimson to almost white, to a dull, blotchy burgundy. The tone may be related to several factors including stress (excitement) level, general health, and environment. Palm Cockatoos can hide the facial patch with coverlet feathers, a behavior that may serve as a social signal or otherwise indicate a bird's state.

A healthy Palm Cockatoo has some powder down. The powder dulls the glossy beak and lends a subtle grey colour to the black plumage. Feathering is sparse on the Palm Cockatoos' black legs.

Palm Cockatoo beaks are unique in their size and structure. The maxilla, or upper beak, is almost twice the size of a Moluccan Cockatoo's (*Cacatua moluccensis*). The beak has great strength for cracking large nuts, but the maxilla is almost hollow in the area below the cere, making it vulnerable to physical trauma. The maxilla has a large biting surface on the underside that opposes the biting edge of the mandible. The mouth is never completely closed because of the structure of the maxilla and mandible. The structure of the mouth is also different than other cockatoos in that the glottis is deep-seated.

1.2 Habitat

Most cockatoo species are adapted to dry climates and associated vegetation. The exception is the Palm Cockatoo, which is adapted to tropical rainforest habitats (Forshaw, 1981; Alderton, 1983; Deifenbach, 1985; Smith, 1987). Evolutionary selective forces in a wetter, warmer climate are very different than those experienced by other cockatoos (Smith, 1987), and Palm Cockatoos have consequently developed many different social, behavioral, and physical traits enabling them to compete in their rainforest environment.

1.3 Social Organization and Reproduction

Unlike other cockatoos, Palm Cockatoos are not flock feeders. They are generally observed singly, in pairs, or in small groups of up to five or seven individuals (Forshaw, 1981; Deifenbach, 1985). It is unknown if these small groups are made up of related or unrelated individuals. Palm Cockatoos roost separately, but begin calling to each other after sunrise (Forshaw, 1981). Small groups congregate on trees in neutral areas during the day, where they preen, perform displays, and engage in various other social interactions (Eastman & Hunt, 1966; Forshaw, 1981; Wood, 1988). Pairs separate from these parties at sunset and return to their own territories. After making a round of sites within their territory, they return to roost, separately, in the same tree (Wood, 1988).

Pairs maintain territories that include several potential nest trees. They regularly visit these sites throughout the year with increasing frequency during the breeding season (Wood, 1988). The Palm Cockatoo's breeding season in the wild is prolonged, and may vary in accordance with climatic conditions (Forshaw, 1981), usually occurring during the months of August through January. The cockatoos inspect nest trees, sometimes adding splintered twigs as nest material, perform displays, and defend their territories from intruders (Wood, 1988). Nest building and maintenance, and territorial defense may be very important to maintain the "pair bond".

Breeding cavities are usually found at considerable heights and are often more than 1 m deep with a diameter of 25 to 60 cm (Forshaw, 1981). Once the pair accepts a nest site, it usually uses it year after year (Deifenbach, 1985). The single egg is incubated by both parents for a period of 28 to 31 days from laying to pipping, with an additional 3 or 4 days to hatch. The hatched chick is totally naked and does not develop down, unlike all other cockatoo chicks which are hisuated (Silva, 1991). The chick is believed to be brooded primarily by the female in the wild. The chick does not emerge from the nest for 100 to 110 days, the longest nestling period known for any parrot species. The chick is not fully competent to fly for about two weeks after leaving the nest, is fed by its parents for an additional six weeks (Forshaw, 1981; Deifenbach, 1985).

Palm Cockatoos are long lived, highly specialized feeders with a slow reproductive rate. As with other large birds inhabiting tropical rainforests, they appear to have a stable population where recruiting younger individuals is normally difficult. Palm Cockatoos have a complex system of calls, displays, and other behaviors unique to the species. They incorporate these vocalizations, displays and behaviors into a rich, complex vocabulary in order to communicate in their heavily forested environment and to maintain the social organization of their family groups and flocks. Close observation of captive birds is necessary to determine behavioral changes that may indicate illness, aggression, societal disharmony, etc.

1.4 Vocalizations

1.4.1 Contact Call
The Contact Call is a disyllabic whistle (Forshaw, 1981; Deifenbach, 1985). Forshaw (1981) noted that the first note is mellow and deep and the second note is high-pitched and shrill with an upward inflection before an abrupt finish. This call is used in flight to, and while displaying at, a congregating tree. See Congregation Display and Social Organization below.

1.4.2 Alarm Call
The Alarm Call is a short harsh, screech, with a strong guttural undertone and is used to warn others of possible danger (Forshaw, 1981; Deifenbach, 1985).

1.4.3 Feeding and Preening Call
A mournful, drawn out, wailing cry is sometimes used when Palm Cockatoos are feeding and preening (Forshaw, 1981).

1.4.4 Flight Call
When the birds are moving from the congregating area to feeding areas and when they are returning to their home territories a deep monosyllabic whistle, repeated three or four times, is sometimes used (Forshaw, 1981).

1.4.5 Juvenile Food-solicitation Call
The Juvenile Food-solicitation Call (Smith, 1987) is a harsh, guttural sound maintained at a constant pitch or level and is used by the chick when begging for food. The chick continues this call while being fed, but due to the "pumping" action of its head, the sound is intermittent.

1.4.6 Growling
In captivity, some birds have been heard emitting a sound which resembles a disyllabic growl and it has been noted by Deifenbach (1985) that, in the wild, they growl while stomping their foot in a threat display.

1.5 Visual Displays

1.5.1 Congregation Display
The bird stands upright with its crest partially raised while giving the first note of the Contact Call. The bird then lunges forward with wings spread, and crest and tail erect giving the second note of the Contact Call (Deifenbach, 1985). This display is performed frequently, two or three times in succession, by mature and immature birds in the congregation tree.

1.5.2 Courtship Display and Copulation
The full courtship display of the Palm Cockatoo is more complex than that of other cockatoo species. The male stretches high with outstretched wings, raises his crest, deepens the colour of his cheek patches and calls excitedly as he advances toward the hen (Sindel & Roberts, 1989).

Copulation of Palm Cockatoos has been observed primarily in the morning after sunrise, but has also been recorded during other periods of the day. The male Palm Cockatoo approaches the female with his wings partially extended. The male's head is upright with his crest feathers fully erect and he bows several times before mounting the female. During this time, he is vocalizing with a very loud whistle. Palm Cockatoos copulate similar to other psittacines, with the male balancing himself on the back of the female. Many other behaviors and displays are also involved in pair formation and courtship. (See Social Organization Section below, and Chapter V, Palm Cockatoo Reproduction for more information)

1.5.3 Threat Display

The Palm Cockatoo raises its crest and advances toward an intruder with slow deliberate steps (Forshaw, 1981). This is followed by growling and rhythmic foot stomping. Territorial conflicts have been observed in which males have fought using their feet, while the female flew beside her mate screeching (Wood, 1988).

1.5.4 Rain-bathing Display

This display is used in the early morning. The cockatoos hang inverted with outstretched wings and tail. This display can be provoked by the sight or sound of rain, sudden alteration in light intensity, as at dawn, or the covering of the sun by a dark cloud (Smith, 1987).

1.6 Unique Behaviors.

1.6.1 Blushing

Unlike any other cockatoo, Palm Cockatoos have a large, naked cheek patch of a reddish colour that deepens in intensity as the birds become excited or agitated (Forshaw, 1981; Freud, 1994). Palm Cockatoos, unlike the macaws, can cover their cheeks by feather movements (Smith, 1987). This ability is useful for thermoregulation and in certain slightly stressful situations they have been observed covering their cheek patches while standing still with crest lowered. It has been postulated that this is a type of hiding behavior due to the fact that they can look like a part of the tree in the low light conditions found in thick rainforest. It may also signal submission to a more dominant conspecific in some social situations.

1.6.2 Foot Stomping

Unlike other cockatoo species, the Palm Cockatoo does not hiss when frightened (Smith, 1987). Under stress, they noisily stomp their feet repeatedly against a perch (Forshaw, 1981; Deifenbach, 1985).

1.6.3 Drumming

Drumming by Palm Cockatoos is a rare example of “tool use” by a bird. Perched upon a dead, hollow tree, holding a stick or nut, the bird drums on the hollow trunk anywhere from 2 to 100 times, creating a considerable sound (Wood, 1984).

1.6.4 Nest Building

Another unique adaptation is the construction of a platform of chewed sticks or twigs within the nest cavity. Both the male and female fill the nest cavity with small pieces of branches that they splinter

off. This activity possibly encourages pair bonding. The platform protects the egg and nestling from flooding during rains as Palm Cockatoos often nest in an open cavity or one with a large opening. It also protects the chick from its own excreta (Muller, 1975; Forshaw, 1981; Deifenbach, 1985, Schubot, 1990).

1.7 Status in the Wild

There have not been many recent surveys concerning the Palm Cockatoo's status in the wild. The only concrete indication of their status comes from the population found on Cape York Peninsula, Queensland, Australia. It has been found that this population is decreasing (Bruning, 1996). Prior to this disturbing report, this population was believed to have been stable. A research project to determine the cause of this decline is being spearheaded by Dr. Don Bruning of Wildlife Conservation International/Bronx Zoo and Joe Forshaw.

1.7a Appended Update on Status in the Wild by Roger Wilkinson

The IUCN Red List (2006) lists the Palm Cockatoo as of Least Concern (see Appendix 1). Recent work (see Forshaw, 2006) indicates however that *Probosciger aterrimus* as previously defined should be split into two sub-species; *P.a.aterrimus* still being restricted to the Aru and Islands off Papua New Guinea and *P.a. macgillivrayi* occurring in southern New Guinea and in Australia on Cape York. Most birds in captivity considered previously to be *P.a.aterrimus* may well be of the subspecies *P.a. macgillivrayi* which is considered Near Threatened (Garnett & Crowley, 2000).

1.8 Diet in the Wild

Palm Cockatoos have been observed feeding on seed, nuts, fruits, berries, and leaf buds. They are primarily arboreal feeders, but have been seen on the ground feeding on seeds and fallen fruit. According to Forshaw (1978), they were observed on the Cape York Peninsula eating seeds of the kanari tree (*Canarium australasicum)* and the black bean tree *(Castanospermum australe)*, and the fruits of the nonda tree *(Parinarium nonda)* and *Pandanus sp.* The outer coverings of some of these seeds are extremely tough, but the fleshy contents are high in oil (Mabberley, 1997) and several cultivars of *Pandanus* have been identified as rich sources of carotenoids, provitamin A and vitamin E (Englberger *et al.*, 2003; Ching and Mohamed, 2001). However a more extensive analysis of wild diet ingredients is lacking. Palm Cockatoos have been observed eating seeds which have passed through cassowaries, possibly making them easier to open or concentrating them into one area. Cassowaries have also been seen eating fruit which has been discarded by foraging Palm Cockatoos (D.Bruning, pers. comm.).

Chapter 2
Housing and Enclosure Requirements
by Sherry Branch from Sea World of Florida
and Ron Young from Mesker Park Zoo

2.1 Aviary Size

Palm Cockatoos *Probosciger aterrimus* are generally housed in typical parrot aviaries, such as flight or suspended cages. Cage size should allow adequate flight and recreation to ensure physical and mental well being of the cockatoos. Deifenbach (1985) states that "Basically, only a large, roomy aviary of stable construction is suitable for keeping these birds. Animals which are not kept in a well-planned flight often appear bored and listless. Kept in a large aviary they are in constant motion and exhibit their interesting behavioral repertoire..." The use of the criterion "successful breeding" to determine minimum adequate cage size does not address welfare issues. Although the smallest enclosure in which Palm Cockatoos have reproduced is 1.3 m x 2.6 m x 1.3 m (length x width x height), the AZA Palm Cockatoo management group and Palm Cockatoo EEP discourage using aviaries this small in the interest of the birds' well being. Furthermore, while some breeding may occur in smaller cages, it may improve with larger cage size: the number of new breeders increased at one institution when pairs were moved from small to larger size cages. Seven out of nine breeding pairs and eight of the ten non-breeding pairs in Europe were housed in enclosures at least $20m^2$ at the time of the European Palm Cockatoo Management Survey.

How much space is needed is at this time subjective, and a thorough analysis of behavior and body condition relative to space would be needed to address it very objectively. Obviously the larger the enclosure the more opportunity the cockatoos have to improve body condition and to carry out diverse behaviors if enclosure furnishings are suitable. The Palm Cockatoo SSP Management Group feels the minimum size aviary to accommodate normal activities is 2 m x 3.3 m x 1.6 m and the optimum would be any aviary larger than 2.6 m x 4 m x 2.6 m. M. Reinschmidt (in lit. to C. King) felt that these dimensions are too small, remarking that Palm Cockatoo enclosures at Loro Parque are 10 m x 2 m x 2.5 m. Forshaw (1981) also recommended more enclosure surface area than suggested in the AZA recommendations (which are $6.6m^2$ for the minimum and $10.4m^2$ for lower end of optimum), stating that "A spacious aviary, not less than 16 m^2 in floor area, should be provided for each pair; in close confinement, the cockatoos become dull and listless."

The height of the aviary can be important in providing the cockatoos with security; a height of at least 2.5 m provides the birds with a chance to perch above human level, assuming that appropriate perching is available.

2.2 Perches

Perches are necessary on both ends of the cage to allow adequate flight. Additional perches of various sizes and diameters are recommended but should not obstruct flight space. The AZA Palm Cockatoo management group recommended that perch diameter be between 5 - 10 cm, however as M. Reinschmidt (*in lit.*) pointed out, Palm Cockatoos do use smaller perches that they can climb on

and destroy. While smaller perches may need more frequent replacing, providing a great variety of perch diameters can only be favorable to the bird's foot condition and behavioral possibilities.

Palm Cockatoos seem to prefer higher perches when given a choice, and the upper level of an enclosure should be well-perched, but with perches placed low enough that birds' crests do not touch the top of the enclosure. Some perching should be provided at different enclosure heights to allow the birds to use the entire enclosure and to allow the birds to space themselves vertically as well as horizontally according to social hierarchical position. One wide perch, e.g. 10 cm to 30 cm in diameter and at least one metre long, should be provided to allow the male to strut and display. The strutting perch should be located away from human disturbance. A vertical perch such as a wooden post or tree trunk is also enjoyed by these birds.

Perches should not be slippery, and should have texturing and/or flexibility that provides some pliancy upon impact, as a flying Palm Cockatoo can land quite heavily. Thick, natural fiber rope serves nicely to provide non slippery, flexible perching, and additionally fulfills a grooming/comfort function, as Palm Cockatoos have been observed rubbing their facial patches and beaks on rope perching. It is necessary to clip long loose rope fibers before they become long, as the cockatoos may otherwise entangle the leg or leg band.

2.3 Substrate

Palm Cockatoos have been housed and bred successfully in enclosures with both cement and natural substrates and also in suspended cages. Many zoos in Europe use sand as a substrate throughout the enclosure, or place sand under feeding areas to facilitate cleaning. One European questionnaire responded remarked that at her facility gravel is used because it is easy to clean and the cockatoos use it for nesting material. Palm Cockatoos often walk on the ground and seem to enjoy utilizing earth or other natural substrates, e.g. volcanic sand, grass and wood/bark chips. Infectious and parasitic diseases can be a problem (See Chapter VII, Medical Management of the Adult Palm Cockatoo for additional details), and may need to be considered in substrate choice in some locations. One questionnaire respondent suggested using coconut chips rather than wood chips, as they absorb water better, not leaving puddles that can be a source bacterial infection.

2.4 Wire and other boundaries

Twelve gauge wire is recommended to contain these birds due to a report that a Palm Cockatoo chewed through 14 gauge wire. When planning a Palm Cockatoo enclosure, consideration should be given to construction of a safety area at the door to prevent the birds from flying out when keepers enter the pen. The pen can be double-wired to deter the cockatoos from escaping by chewing out of the exhibit. Leaving a space of several centimetres between the two wire boundaries can potentially help to prevent injuries from aggression that may occur if a cockatoo is housed adjacent to other animals (con- or heterospecifics). Small diameter meshing helps deter entry of local birds and some pest species, but is more difficult for the parrots to climb on. The meshing should be welded so that it does not jam or seize feathers. Glass on the enclosure sides facing visitors may be preferable if

there is a problem with the cockatoos being fed by the public.

2.5 Indoor or Outdoor?

The AZA Palm Cockatoo Management Group has found that Palm Cockatoos breed better if they have access to an outside enclosure. Six of the nine breeding pairs included in the European husbandry questionnaire had access to both indoor and outdoor areas, two (located in the Canary Islands, Spain and South Africa) had access to only outside areas, and one (one of three parent-rearing pairs) had access to inside only.

2.6 Cold Weather

Palm Cockatoos do well in outdoor exhibits, but should be kept in a heated area when temperatures fall below -4 °C. They also need an indoor heated area in locations where the ambient temperatures go below freezing (even slightly) for more than a day or two. Wind breaks and heat lamps may provide adequate protection for birds located in areas which experience freezing weather for less than 24 hour periods. It is important to ensure that the cockatoos do indeed use the heat lamps. A lamp should be provided for each individual in most cases, as a dominant bird may keep subordinate birds away from a lamp.

2.7 Hot Weather

At least one area of the exhibit should be covered to provide the birds the opportunity to find shelter and shade. In very hot climates, it is important that these dark plumaged birds are able to get completely out of the sun. Misters or showers can also provide relief during hot, dry weather.

2.8 Disturbance

The AZA management group and the Palm Cockatoo EEP Species Committee recommend limiting human disturbance to the nest. The birds can be monitored via video cameras to detect breeding behaviors or parental neglect. The European survey suggested that daily maintenance of enclosures does not necessarily disturb breeding behavior: six of the nine breeding pairs were in enclosures with daily maintenance, including two of the three pairs that parent-reared chicks.

Conspecific group sizes and considerations concerning which other species to house with, or near, Palm Cockatoos is discussed in chapter 4.

2.9 Location of Feeders

Feed stations should always be located under shelter, in an area that creates the least disturbance to the birds. Palm Cockatoos do not like going into a box-like feeder, but may accept food bowls

placed inside a wire basket. Birds reach through a hole in the top of the basket to feed, but are unable to tip the bowl. (See Appendix 4, Basket diagram). Feeders should be rodent proof.

2.10 Water

The Management Group recommends that fresh, clean water be given to Palm Cockatoos daily. Water may be provided in a variety of ways, from a standard water dish to a free flowing pond. Some Palm Cockatoos tend to tip and empty their water bowls, this should be considered when deciding upon which water source to use. (See Appendix 4, Basket Design)

2.11 Sanitation

Food and water bowls should be cleaned and disinfected daily. Several varieties of disinfectants have been used, but bleach is probably sufficient. After washing, the bowls should be soaked or dipped into the disinfectant solution. If the birds have access to food dropped on the floor of the cage, the food should be removed from the pen before it molds. Placement of sand or matting under the food dish in enclosures with organic substrates makes it easier to dispose of food on the ground, however if the cockatoos do pick up food from sand substrates they are likely to also ingest sand which can accumulate in the stomach, causing health problems.

2.12 Nest Boxes

Nest sites should be provided for breeding. The Palm Cockatoo SSP Management Group commented that more than two boxes may detract or confuse the pair. Pairs in the wild maintain several nest sites, visiting them frequently and dropping nest material in them (Wood, 1988), and this behavior may strengthen the pair bond (see also section 1.3: social organization and reproduction). It was found that three breeding pairs at Rotterdam Zoo also performed this behavior when given several nest sites. This was viewed as desirable natural behavior; it is believed to possibly stimulate nesting activity and certainly did not interfere with it.

There seems to be no need to furnish Palm Cockatoos with natural nest cavities (i.e. hollow logs) to entice them to nest. The European questionnaire indicated that three of 12 pairs offered nest logs nested in these, and one pair parent-hatched offspring. Six of eight pairs offered a nest box nested in it, and four pairs parent-hatched young. Both open nests and closed top nests with large entrance holes were used. Open-top boxes, with a minimum 60 cm of clearance to the top of the cage, have been the most successful in North America: a rectangular box situated on end is the generally accepted type. A nest box constructed from “Trespa” an extremely hard material formed from laminated layers of paper pressed together under high pressure, with a long, slanted entrance was preferred above nest logs and barrels by one parent-rearing pair of Palm Cockatoos**.** The Palm Cockatoo SSP Management Group recommends that the nest box be between 1 m to 1.3 m deep. Any deeper may cause the birds to spend too much time filling the box with nesting material. (See Appendix 2, Nest Box Examples)

2.13 Nesting Material

Palm Cockatoos create their own nesting material from soft branches such as eucalyptus, bamboo, acacia, and willow. M. Penning (pers. comm. to C. King) noted that blue gum branches were an important trigger in egg-laying of Palm Cockatoos at Umgeni Bird Park in South Africa. The cockatoos splinter the branches and take the pieces into the nest, all year round, as mentioned above. The birds may become frustrated if there are long periods when they do not have access to nesting material. In at least one instance, aggression to the female by the male was thought to be the result of this situation. A good rule of thumb is to give the birds new branches as soon as they finish the previous branches to ensure they have a constant supply.

2.14 Environmental Enrichment

Environmental enrichment can be defined as "additions to the enclosure that enable an animal to perform behavior patterns similar to that of wild con-specifics". The practice of supplying branches and providing a wide perch for male strutting or displaying behavior are two examples of environmental enrichment. As mentioned above thick, natural fiber rope may also be well utilized by Palm Cockatoos: the birds not only use the rope as a perch but also for grooming; they frequently rub their cheek patches on the rope. Palm Cockatoos number among the tool-using avian species,: they drum by beating a hollow tree trunk with an object, such as a stick or nut held in one foot, in what appears to be a territorial display (Wood, 1984).

Palm Cockatoos explore live vegetation such as shrubs and trees, and may at times attack it, but at least at Rotterdam Zoo the vegetation has survived. Vegetation also provides opportunities for the birds to get out of visual range of conspecifics. Vegetation can also be instrumental in increasing humidity in the enclosure. Palm Cockatoos also enjoy playing in and exploring organic material (leaves, brush) left on the ground.

Many environmental enrichment activities focus on foraging, for example hiding food items or making them more difficult to access so that the cockatoos need to work harder to obtain them.

Chapter 3
Management
by Susan Healy from the Sacramento Zoo

3.1 Individual Identification

Permanent individual identification is crucial for keeping track of individuals and maintaining accurate health and genealogy records. This is especially important so that birds can be tracked both within and outside the managed population.

3.1.1 Transponders
The Palm Cockatoo SSP Management Group and Palm Cockatoo EEP Species Committee strongly recommend that all Palm Cockatoos be permanently identified with a transponder. The birds should be implanted intramuscularly in the left breast muscle.

3.1.2 Leg Bands
Closed leg bands should be used for captive-hatched chicks. The bands should be stainless steel instead of aluminum because a Palm Cockatoo is capable of crushing an aluminum band on its leg. Open leg bands are not recommended because they have been known to catch on the side of the cage causing injuries and deaths. Ring size is reported to be 12-14 mm internal diameter.
[Appended note: A ring size of 14 or 16mm internal diameter is used at Palmitos Park, pers. comm.. from Kira Salvita to C. King]

3.2 Handling

The recommended capture method is either netting or toweling, depending upon the size of the enclosure. A net is the preferred tool when attempting to capture a bird in a large pen, but if the bird is in a small cage where they cannot fly away easily, a towel thrown over the bird works well. Palm Cockatoos should be handled the same as other psittacines by securing their head with one hand, being careful not to be bitten, and securing their legs and wing tips with the other hand. Some Palm Cockatoos may be prone to prolonged effects from being caught. After they are released back into their pen they show signs of being depressed: crest lowered tightly to their head, not moving about, being very quiet, and their cheek patches stay pale in colour. After a time, normal behavior returns.

3.3 Shipping

A size 100 or 200 plastic kennel with metal windows and doors is recommended when shipping these birds. Wooden crates are also used for shipping (See Appendix 3, Shipping Crate Diagram used by ABRC). Some type of bedding material, such as straw or wood shavings, should be provided to prevent the birds from slipping on the floor of the crate. A secure perch, bolted to the floor or sides of the container can also help stabilize the birds. Providing the birds with food, such

as nuts and fresh fruit, is recommended during shipment. Water is unnecessary and not recommended for **short** flights. The water dish itself can be hazardous to the bird and the water usually sloshes out which can cause additional problems. The birds will get the moisture they need from the fresh fruit provided.

Appended information for the transport of Palm Cockatoos within Europe:
All airlines will require that IATA guidelines are complied with (www.iata.org/ps/publications/9105.htm for details) for all air travel. Palm Cockatoos are also listed as CITES I, Annex A so will require the relevant documentation associated with the trade of all CITES I listed species; the precise requirements for this documentation will be dependant upon the country of export and import. Additionally, as with all Psittacines, Palm Cockatoos, require statutory health export documentation prior to international transfer (TRACES within EU).

3.4 Pest Control

As with all avian species, rodents and other vermin can be a problem. The size of the wire mesh will determine cage accessibility.

The following are some suggestions to reduce incidents of pest problems:

1. It is recommended that food storage and preparation areas are clean and free from debris.
2. Rodent proof and screen all doors (including overhead types), windows and other openings such as vents.
3. Keep doors and windows to the outside closed when not in use. This reduces the potential entry of rodents, insects and birds from the outside.
4. Grounds maintenance around the building should include removal of debris and elimination of storage against the building such as pallets, trash containers, racks, etc.
5. All ground cover and decorative plantings should be kept trimmed back 18 inches from the walls to create a barrier which reduces pest entry into buildings.
6. Damaged containers should be eliminated as soon as possible since such containers are conducive to pest development and infestation.
7. Utility rooms and mechanical rooms should be kept neat and clean. These rooms should not be used as storage or stock areas.
8. Care should be taken to see that all equipment is cleaned on a regular basis.
9. All switch boxes, electric motors and similar type compartments should be cleaned and checked regularly.
10. Drains must be kept free of debris and garbage at all times.
11. All inside garbage and trash containers must be kept clean and dry under the plastic liners.
12. Moisture problems and water leaks must be repaired immediately.

Be sure to follow your institution's individual pest control procedures.

Chapter 4
Intraspecific and Interspecific Social Management in Captivity
by Pat Rider and Mike Taylor from the White Oak Conservation Center

4.1. Conspecifics

4.1.1 Pairs

The Palm Cockatoo SSP Management group and the Palm Cockatoo EEP Species Committee recommend that Palm Cockatoos be kept in pairs for breeding. Holding Palm Cockatoos in groups seems to depress reproductive behavior, based on experiences at Rotterdam Zoo and several South East Asian Zoos. Serious and even fatal aggression between Palm Cockatoos housed as pairs may occur (See Chapter VII, Medical Management of the Adult Palm Cockatoo, Common Injuries and Treatments Section for mate trauma). Males are usually the aggressors, but sometimes females are. While a few incidences of aggression have occurred between established pairs, most have been between recently introduced pairs within the SSP population, and great care should be used when introducing Palm Cockatoos (see section 4.2, Introductions). Three respondents in the European husbandry survey noted a link of aggression with indoor confinement and three noted a link with courtship. Two noted that aggression was linked to chick rearing and presence of fledged young. One respondent reported a link between aggression and feeding and another with incubation. There were no reports of aggression associated with introduction in this survey.

Bouts of intra-pair aggression associated with an event or process can sometimes be alleviated by holding one of the birds (usually the aggressor) in a holding cage within the enclosure or in an adjacent enclosure for as long as necessary. A few hours or a day was found to be sufficient in some instances at Rotterdam Zoo. An aggressive female Palm Cockatoo held in an enclosure next to a recently fledged young and father continued to feed the young through the fencing at Loro Parque (King 2000a, 2000b, R. Sweeny pers.comm.).

The application of a surgically attached acrylic “beak ball” to the maxilla of a male cockatoo, reducing his ability to inflict a deep wound, was used at ABRC to reduce intra-pair aggression. In some cases application of one ball (which remained in place for 24 to 51 days) allowed time for the male’s aggressive behaviour to subside, but in other cases the application of a second beak ball was necessary (Clubb *et al.*, 1992).

4.1.2 Non-breeding Palm Cockatoos

Palm Cockatoos can be kept in groups from 2 to 20 birds, and it is strongly recommended that an individual of this social species not be housed alone unless it is incompatible with conspecifics of both sexes. Most of the Palm Cockatoo SSP birds are kept in pairs with a few being kept as two of the same sex. One SSP facility has kept up to 20 young hand-raised birds of similar ages together in a large flight cage with no adverse effects. Palm Cockatoos have also mostly proven to be usually non-aggressive when housed in large, adult con-specific groups. They are generally peaceful birds and have a rich vocabulary of displays and vocalizations that are used to maintain social harmony and to exclude outsiders from their territories. It was found during observations of a group of 5.2 Palm Cockatoos at Rotterdam Zoo that behaviors normally interpreted at pair-behaviors such as

allofeeding and allopreening occurred in other social contexts and among a variety of individuals of the same or different sexes. These behaviors may function to deter aggression, as no overt aggression was observed. While aggression seems to be reduced in large group exhibits of adult birds, some killings have nonetheless been reported, and interactions among group-members should be regularly monitored.

Serious aggression occurred within a group consisting of an adult female and two immatures one year apart in age, when the birds were moved to a considerably smaller amount of space for a short time.

4.2 Introductions

4.2.1 Methods used to introduce Palm Cockatoo pairs

1. The male is introduced into the female's pen, giving her the home turf advantage.
2. The male and female are placed in adjacent pens to get acquainted then placed together into either her pen or into a neutral pen.
3. Both birds are placed into a neutral pen without an acquaintance period.

4.2.2. Guidelines for introductions of pairs and larger groups:

- Caution should be taken with every introduction.
- After quarantine, it is a good idea to house a new bird in close proximity to the individuals with which it will be housed so that the birds have time to become acquainted before a complete introduction is attempted.
- Following the introduction, the birds should be observed as much as possible.
- Do not introduce a female into a male's pen.
- Do not introduce a young female to an older male without using ample caution and observation.
- If a particular Palm Cockatoo is repeatedly found on the floor of the enclosure, aggression from an enclosure mate is probably the cause. One of the birds should be removed from the cage at this point. It is possible to try them together again at a later date, but close observation is needed, due to the low probability of the pairing (or other social situation) working out.
- Introductions of larger groups should probably proceed much the same as pairs: the entire group could be introduced to a neutral enclosure simultaneously. Introduction of one individual to an existing group might be more difficult, particularly if it is an adult group. The bird should be placed an adjacent enclosure with visual access to the enclosure first. Thereafter the most dominant birds in the enclosure might need to be removed before introducing the new bird to the enclosure, and introductions with different group members gradually made.
- Ensuring that there are adequate feeding opportunities and perching at different levels and locations throughout the enclosure can be of critical importance in success of introductions.

4.3 Pair Formation

Allowing some choice in pair formation could be very important in formation of successful pairs as demonstrated when allowing pair formation to occur among groups of 2.1 Palm Cockatoos at three different zoos (King, 2000a, 2000b). A trio, either 1.2 or 2.1, can be placed into three adjacent pens with the single sex bird in the center pen, allowing the single bird to choose. The three birds can also be placed in the same enclosure (as was done in the aforementioned three situations) but this requires more intensive observation to ensure that aggression does not occur. In this situation all three birds should be introduced to a neutral enclosure or two males introduced to a female's enclosure.

4.4. Mixed Species Enclosures

The AZA Palm Cockatoo Management Group does not recommend housing Palm Cockatoos in mixed species enclosures, in order to avoid intra-specific hostilities. Palm Cockatoos were tried with other cockatoo species at Rotterdam Zoo, but eventually resulted in aggression towards the other species and possibly repressed reproductive behavior of these species. They were also found to be incompatible with a macaw species at Umgeni Bird Park. The Palm Cockatoos were compatible with smaller columbiformes and several species of medium-sized ground birds, which also bred in the presence of the Palm Cockatoos (King, 2000a). They did not get along well with Blue-faced Honey Eaters *Entyomyzon cyanotis* or Megapodes *Aepydodius arfakianus* however.

If placed in a mixed-species exhibit, the selection of enclosure mates should be carefully made, close observation, attention to details (e.g. accessibility of perches and food) that will reduce possibility of conflict and common sense should be used.

4.5 Proximity of Conspecifics and Other Avian Species

It is also important to consider which species are housed in the vicinity of Palm Cockatoo pairs. The AZA management team advises housing pairs away from other psittacines, especially macaws, as Palm Cockatoos are considered shy, and some pairs have became reproductively active only after being moved to more secluded enclosures. Contrarily, some of the Palm Cockatoos that have bred in European institutions have been in close proximity, if not adjacent to a variety of psittacine species (see also 4.4).

Housing Palm Cockatoo pairs in very close proximity to other adult Palm Cockatoos may influence breeding behavior, and probably should be avoided.

Chapter 5
Palm Cockatoo Reproduction in Captivity

by E. Trent Swigert from the Caloosahatchee Aviary and Botanical Gardens
formerly from the Avicultural Breeding and Research Center

5.1 Rearing Recommendations

While there is concern in the Palm Cockatoo EEP about negative population growth, EEP participants are encouraged to allow pairs to parent-rear whenever possible. It is not unusual for a pair of parrots to fail in the first nesting attempts as they gain experience. If a pair continues to falter at the same stage of incubation/parent-rearing, observation with a video nest monitor may indicate where the problems lie. If necessary, eggs or chicks can be taken for artificial incubation and hand-rearing.

5.2 First Captive Breeding

Palm Cockatoos have successfully bred in a number of private and public institutions throughout the world in recent years. The world's first documented captive breeding of this species occurred in 1968, by Bob Lynn of Sydney, Australia. The chick was reportedly reared to full term by its parents (Low, 1993).

5.3 Breeding Season

Palm Cockatoos have reproduced in every month of the year at the Avicultural Breeding and Research Center (ABRC) in Florida, USA. New York Zoological Society's Palm Cockatoos at the Wildlife Survival Center in Georgia, USA, also located in the southern US, produced eggs in all but two months of the year. Breeding has been varied and sporadic at other institutions in the US. Eggs have been laid in all months in Europe, according to the European management survey. Of 52 eggs laid by 9 pairs the most were laid in April (8) and the least in January (1) and July (1). The first egg laid by each of 7 pairs was also variable: January (1), April (2), June (1), August (1) and November (2).

5.4 Breeding Stimulus

There seems to be no specific stimulus which consistently triggers the Palm Cockatoo to breed in captivity. Some aviculturists previously believed that Palm Cockatoos had to be fed a diet consisting of natural food items found in the wild, such as the fruit of the Pandanus plant (*Pandanus sp*.), to stimulate breeding. This theory has been proven false by a number of the facilities which have bred this species. Similarly six of the seven pairs included in the European husbandry survey that produced chicks in Europe, including all three parent-rearing pairs never receive Pandanus fruits or palm fruits/hearts.

Photoperiod has not been indicated as an important factor in triggering reproduction, however it may influence results more than one might expect, as was found with cockatiels. Availability of nest sites and appropriate nesting material is important however.

5.5 Sexual Maturity

A female Palm Cockatoo believed to be two years of age based on plumage and bill colour maturation produced offspring after 5 years at ABRC. Likewise a parent-reared female from Leipzig Zoo bred at Rotterdam Zoo at 7 years of age. Her egg was fertilized by a male more than 29 years of age. Estimates on age of reproductive maturity will be more accurate when the F1 generation begins reproducing.

5.6 Artificial Insemination

At the present time, there has been no research in the area of artificial reproduction methods with Palm Cockatoos semen collection and insemination attempts with other species of psittacines have yielded poor results. If, in the future, these techniques can be perfected, semen from unrepresented founders could possibly be collected and stored for later use.

5.7 Egg Management

The Palm Cockatoo EEP Species Committee advocates disturbing pairs as little as possible throughout the reproductive period. This species is managed much more "hands-on" at ABRC. Nest boxes of Palm Cockatoos are checked every other day if breeding behavior has been observed, however if the pair is shy or very nervous when approached its nest is checked weekly. Most eggs have been discovered in the morning; on occasion a female will lay in the afternoon. A female may have a very pale facial colouration the day she lays; this should not be mistaken for a health problem.

Once the egg is discovered in the nest box, it is examined for imperfections. If there are any cracks, these are sealed with any kind of fingernail polish; fingernail polish provides a better seal and dries much quicker than the more commonly used glue. The egg is then placed in the incubator. ABRC has had better success incubating Palm Cockatoo eggs using artificial incubation from day 1 than using foster parents (Eclectus Parrots *Eclectus roratus* and Bantam chickens). A pair of Eclectus Parrots at Rotterdam Zoo that had successfully foster-reared another parrot species hatched a Palm Cockatoo but the chick was found injured and dead after one day. It was not clear whether injuries were the cause of death or occurred thereafter.

Dependable pairs at ABRC are given the opportunity to incubate the egg for approximately 14 to 20 days before the egg is pulled for artificial incubation. Eggs in the nest box are candled for signs of fertility after 10 days. Infertile eggs are removed and placed in the incubators for two additional

days in case the parents had not been sitting the egg properly.

Prior to the placement of a fertile egg in the incubator, the egg is candled to check its progression, and measurements are taken of the egg's length and breadth. If the egg is pulled soon after it is laid, a fresh egg weight is also recorded prior to placement in the incubator. The following charts show the average fresh egg weight, hatch weight and measurements of normal Palm Cockatoo eggs based on data collected from a sample population at ABRC.

5.8 Egg Measurements

Calculations for *P.a. aterrimus* eggs.

Measurements	n	Mean	Range
Fresh Egg Weight (mm)	27	26.22	23.44 - 29
Breadth (mm)	39	32.94	31.94 - 33.94
Length (mm)	39	45.66	42.57 - 48.75
Hatch Weight (g)	38	17.9	16.1 - 19.7
% Weight Loss	27	13.97	12.33 - 15.61

Calculations for *P.a. goliath* eggs.

Measurement	n	Mean	Range
Breadth (mm)	13	35.09	34.59 - 35.59
Length (mm)	13	49.72	48.15 - 51.29
Hatch Weight (gm)	13	20.97	19.98 - 21.96

n= the number of individuals in the sample population.
The range is $\pm$ 1 standard deviation from the mean, so the measurements of 68.26% of Palm Cockatoo eggs should fall within these ranges.

5.9 Artificial Incubation

The temperature setting for the incubators at ABRC is a dry bulb reading of 37.5°C and a wet bulb reading of 28°C to 29°C, or 48% humidity. The Grumbach incubator uses rollers to turn its eggs while the Humidare uses a tilted tray. Even though automatic turners are used, ABRC recommends turning the egg by hand one quarter rotation at least three times a day for the first two or three weeks. The egg is turned twice a day during the remainder of the incubation period. The temperature in the hatcher should be lowered to between 36°C to 37°C), with the wet bulb increased to 33°C to 34°C to aid in the hatching process. An extra pan of distilled water can be placed in the hatcher to increase humidity.
[Appended note for EEP:, ZooParc de Beaval move their eggs between three Grumbach incubators of 70-75%, 45-50% and 30-35% humidity, and with a temperature of 37.2 ^{o}C – 37.4^{o}C. (pers. comm. Roman Potier to C. King)]

5.10 Hatching

Palm Cockatoo eggs can be candled regularly to monitor their development. Once the embryo progresses to the draw down stage of development it should be placed on the bottom of the incubator and no longer turned. This allows the embryo to position itself for internal pipping. The time period from internal pip to external pip is between 24 to 48 hours. After the egg has externally pipped it should then be placed in a container and moved to the hatcher. The eggs can also be candled in the hatcher to make certain there are no problems during the hatching process. The hatching time is between 48 to 72 hours. Palm Cockatoos take longer to hatch than other psittacines. ABRC assists hatches only after 72 hours, or if we feel there is a problem with the chick. The newly hatched Palm Cockatoo chick should be weighed, given an identification or accession number, and then transferred to the nursery where the hand feeding process begins.

Chapter 6: Nutritional Requirements of Adult Palm Cockatoos

By Andrea Fidgett from the North of England Zoological Society

The nutrition section is based primarily on general knowledge of the nutritional requirements of birds, and successful diets and practices with psittacines in particular. Additional information comes from a survey by Marquardt and Howard (1998) using a questionnaire distributed to North American facilities that bred or displayed Palm Cockatoos, and a more recent husbandry survey of equivalent European collections.

6.1 Nutrient Requirements

Psittacines, like other animals and humans, do not require particular food items: rather, they require nutrients (water, amino acids (protein), minerals, vitamins and essential fatty acids) in specific quantities. Even so, these nutrients should be presented in feeds appropriate to the species' digestive morphology. These birds are highly intelligent animals that require a great deal of stimulation in captivity and diets tend to be diverse, offering ingredients varying in colour, shape and texture as means of providing enrichment. Research on particular nutrient requirements for altricial birds is very limited and there is none specific for Palm Cockatoos. Roudybush and Grau (1985) studied protein and lysine requirements of cockatiels and research populations of such easily propagated species have been used to examine other nutritional aspects (see Koutsos *et al.*, 2001 for comprehensive review). Ullrey *et al.* (1991) extrapolates from nutritional studies on precocial birds to suggest preliminary guidelines for feeding psittacines.

6.2 Captive Diets

The diet consumed by free-living birds can rarely be duplicated in captivity because the food items they consume are not usually available or cultivated in sufficient quantities. Instead birds have been successfully maintained on seed mixes (consisting mainly of sunflower seeds) with extra ingredients included like whole corn, dried red peppers, other seeds and grains. Many facilities also use dried biscuits made for dogs or primates and while not harmful, these diets are not formulated to meet the nutrient requirements of birds. Captive diets for Palm Cockatoos can be more varied, often dependant upon seasonal availability of feed items. See Table 1 for selected nutrient composition data for commonly used ingredients in Palm Cockatoo diets.

'Natural' food ingredients and some limitations

The nutritional characteristics of seeds from domestic plants cultivated on a large scale (as found in most commercially-sold seed diets) are quite different from those of native plants. Seeds from domestic cultivars are more concentrated in energy and lower in protein and many other essential nutrients than seeds available in the wild (Allen and Hume, 1997; Klasing, 1998). The high fat content of seeds is responsible for their energy value and also makes them very palatable. Unlimited feeding of seed mixes can lead to consumption beyond energy requirements and obesity in a number of parrot species (Ullrey et al., 1991). Palm Cockatoos tend to be lean birds and obesity has not been

recorded as a problem. While energy requirements are met, seeds otherwise provide poor nutrition: low quality protein, high levels of fat; poor mineral content and of concern for young or reproductively active animals (particularly females), an imbalanced calcium:phosphorus (Ca:P) ratio (Klasing, 1998; Schoemaker, 1999).

Producers of seed diets attempt to overcome nutritional deficiencies in a variety of ways, including adding manufactured components (extruded or pelleted diets) to the seed mixture, and/or coating the hulls of the seed with vitamin and mineral solutions. Birds still tend to select the more palatable seeds, leaving the pellets uneaten and by de-husking seeds (behaviour the birds are anatomically adapted for), the expensive vitamin and mineral coating remains on the hulls leftover in the feeding dish. A more sensible strategy is to restrict the quantity of oily seeds (e.g. sunflower, hemp) and nuts fed.

Nuts were found to be a favoured food item of Palm Cockatoos in 15 of the 17 zoos responding to the European husbandry questionnaire. Many varieties of nuts can be given in addition to manufactured diets: pine (pinyon) nuts, almonds, peanuts, coconuts, hazel nuts, walnuts, macadamia nuts, pandanus, pecans, and fruit from the queen palm (*Syagrus romanzoffianum*). Nuts should always be offered in limited amounts either daily or occasionally to ensure adequate consumption of the manufactured diet (if used).

Fruit is another common component of captive diets since it is readily available in zoos, highly palatable and offers variety of colour, taste and texture. But most of what is available has been cultivated for human consumption and once again, domestic fruits are nutritionally inferior to fruits consumed by birds in the wild, tending to contain higher levels of sugar and less protein (Oftedal and Allen, 1996). Vegetables are also readily available and can supply similar enriching attributes of colour and texture, whilst being a better source of important nutrients. Dark green leafy vegetables (but not lettuce) are an excellent source of calcium and phosphorus in a ratio favourable for skeletal development and egg production.

Beans and pulses are a good food group for diets since they contribute high quality protein, low fat and less sugary carbohydrates for energy. Many are highly palatable e.g. mung and soya beans, and chick peas, however red kidney beans should not be used since they contain a component believed to impede the uptake of calcium. Care is required in the preparation and presentation of pulses since they should all be soaked for 24 hours before use, changing the water often during that time to prevent microbial or fungal growth and contamination, particularly if stored in warm, humid conditions while soaking and/or sprouting. It is vitally important that the pulses are thoroughly rinsed before being fed out to birds. Boiling of pulses is not recommended as it diminishes both the quantity and the quality of the proteins and leaches out minerals to the boiling water.

Manufactured (pelleted or extruded) Diets

While manufactured or pelleted diets may not appear stimulating to the birds (or their keepers), most good quality established brands contain a balance of nutrients otherwise difficult to guarantee in the 'natural' food items already described. These include minerals, fat-soluble vitamins and the specific amino acids (lysine and methionine) known to be limiting in avian nutrition. Furthermore, the consumption of pellets is easier to monitor than the use of broad spectrum 'supplements' that often come in a powder form and are sprinkled over the diet once it has been prepared. Feeding of

manufactured (pelleted or extruded) diets forces the birds to consume a diet with a nutrient profile designed to meet nutrient requirements of psittacines. While a manufactured diet can provide the bulk of the nutrition, most are formulated to allow quantities of suitably nutritious fruits and vegetables plus limited amounts of seed or nuts that provide variety in the diet or can be used for training purposes. Although not a strictly controlled study, Ullrey *et al.* (1991) compared reproductive success in various parrot species when seeds were replaced by an extruded diet; fruits and vegetables were also offered as part of both diet regimes. Fledging success was greater when the manufactured diet was used in place of seeds.

Several companies manufacture diets for psittacines (see Table 2 for a selection of products available in Europe). It is important to select a brand from a reputable manufacturer that has a good quality control program and has tested its product with breeding facilities. Since products may differ in nutrient content and since other food items are typically added to the diet, care must be taken to select a product that will provide adequate nutrient concentrations even when those nutrient concentrations are diluted due to the other food items. The manufactured formulation of the diet and its nutrients should be periodically checked as any changes made by the manufacturer may affect the nutrient status of the birds.

Care should be taken when converting birds from seed diets to manufactured diets (or during any other dietary transitions) to ensure adequate consumption of the diet. Ghysels (1999) describes various conversion methods and makes many useful suggestions on how this can be done successfully (see Box 1). Any diet conversions should involve monitoring body weight (to detect fluctuations) and food intake (accounting for all food wasted such as seed hulls and chaff).

Box 1. Conversion method for transferring birds to pellet feeding.

With the *alternate day method* the birds are offered either pellets or seeds during the whole day. The number of days during which pellets are fed, is increased gradually, always followed by one day seed feeding. This day of seed feeding allows the bird to regain some energy in case they have not eaten enough during the pellet days.

Example of five week feeding schedule for alternate day method of transferring birds to pellet feeding

Alternate Day Conversion Method									
D1	Pellets	D8	Pellets	D15	Pellets	D22	Pellets	D29	Pellets
D2	Seeds	D9	Pellets	D16	Pellets	D23	Seeds	D30	Pellets
D3	Pellets	D10	Seeds	D17	Pellets	D24	Pellets	D31	Pellets
D4	Seeds	D11	Pellets	D18	Seeds	D25	Pellets	D32	Pellets
D5	Pellets	D12	Pellets	D19	Pellets	D26	Pellets	D33	Pellets
D6	Pellets	D13	Pellets	D20	Pellets	D27	Pellets	D34	Seeds
D7	Seeds	D14	Seeds	D21	Pellets	D28	Seeds	D35	Pellets
								D...	Pellets

Some practical tips
- Convert only healthy birds. If possible weigh the birds regularly and make a record of their nutritional situation.
- Young birds will adapt more easily to a new diet than older birds. Birds fed with a more varied diet will also more readily accept a new kind of food.

- To make the pellets more attractive, a sweetening agent, for example fruit juice, honey or syrup, can be added. But make sure the birds are already accustomed to this taste by adding it to their current food.
- Installing a tray filled with pellets close to their favourite sitting place allows the birds to inspect the pellets at leisure.
- Offering the pellets throughout the day, and the current seed mixture only for a few hours will hasten the conversion process. Seeds should then be presented in the evening, so that the bird is hungry enough during the day to try out the pellets.

Adapted from Ghysels (1999)

6.3 Feeding Practice

Birds eat a quantity of food to satisfy their energy needs, which can be calculated using ideal body weight and an estimate of maintenance activity (see box 2). An optimal diet for Palm Cockatoos should provide ~525kJ of energy daily and Table 1 shows energy yield from various feed ingredients.

Box 2. Estimating daily energy requirements of Palm Cockatoo

First calculate the amount required for maintaining basal metabolic rate (BMR), i.e. the rate when sitting at rest and not active, using the formula for non-passerine birds (Robbins, 1993):

$$Energy\ (kJ) = [73.5 \times Mass\ (kg)^{0.73}] \times 4.184$$

For Palm Cockatoos an average adult weight of 1kg would mean:

$$Energy\ (kJ) = [73.5 \times 1^{0.73}] \times 4.184 = \sim 300\ kJ$$

As a general rule, daily energy requirements for captive animals are calculated as between 1.5-2 x BMR. Assuming moderate activity and a factor of 1.75:

Daily energy = 525 kJ

In addition to the energy requirements described above, the diet should meet the following nutrient recommendations. These are provided as a guide only and are ranges for psittacines, based on National Research Council requirements for domestic fowl and diet nutrient amounts that have been successfully used in zoos.

As % dry matter in diet		
Protein	Ca	P
12 - 22	0.6 - 2.75	0.4 - 0.6

The higher protein value is recommended for females laying eggs or rearing chicks. The ratio of calcium to phosphorus should be at least 1:1, but increase for egg production to 2:1.

A good strategy and one which compliments the feeding ecology of the birds is to allow free access to the manufactured diet (this allows the bird to consume food at anytime it pleases and decreases

competition between or among birds) while providing the additional items once or twice per day. To achieve this, a diet might comprise two feeds (e.g.)

1st (main) feed	%	2nd (enrichment) feed	%
Pellets (unlimited, but at least)	30	Fruit*	10
Pulses*	20	Nuts/Seeds*	20
Vegetables*	20		

For items marked with * the choice for inclusion is fairly extensive, however it is recommended that no more than 2-3 different types of each be presented at any one meal. A different selection could be offered on consecutive days to provide variety. Fruit and vegetables should be fresh and as much variety as possible should be given. Although the availability of fruits and vegetables fluctuates seasonally, a variety can be fed daily; the amount needs to be restricted to ensure consumption of the nutritionally complete manufactured diets. Apples, oranges, broccoli, corn, yams, carrots, beets, bananas, pomegranates, grapes, beans (all types), different kinds of leafy greens, and celery are some examples. It is a good idea to vary the diet slightly each day, to make life a bit less predictable for the birds.

6.4 Supplements

Generic multi-vitamin/mineral/amino acid supplements are not necessary if the birds consume an adequate amount of a nutritionally complete manufactured diet. Adding supplements to the diet indiscriminately could potentially lead to an imbalance or toxicity of nutrients. However if the birds are not fed a manufactured diet or if they are sick, adding a supplement may be warranted and a variety of additives are available on the market today. Cuttle bone, which is 85 % calcium carbonate (calcium carbonate is 40% calcium), is a favourite of Palm Cockatoos at ABRC when not offered manufactured diets but is generally unnecessary if the manufactured diet is appropriately formulated and consumed by the birds.

6.5 Reproductive/Parent-rearing Dietary Changes

Enhancing the nutritional plane of the diet before the start of the breeding season and thereafter during the rearing period is likely to be beneficial, providing the female with extra nutrients for both egg and chick production. A conditioning diet, often egg-based, will provide a broader spectrum of nutrients (protein, vitamins and minerals) for this purpose and parrot 'breeder' pellets provide similar nutritional benefits. Ensure cuttlefish is always available ad libitum. It may be ignored for many months, but when a female is producing eggs it will likely then be consumed in large quantities. Several respondents in the European husbandry questionnaire noted an increase in fruits and vegetables used during the breeding season. One respondent specifically mentioned pomegranate, and Low (1993) also was convinced that consumption of one or two pomegranates a day were important in the success of a pair at Palmitos Park.

6.6 Example Palm Cockatoo Diets

Below are sample diets used by institutions that have had breeding success with Palm Cockatoos.

6.6.1 ABRC

percent contribution to total diet by weight, as fed	
1.0 %	Nuts: Peanuts, brazil nuts, hazel nuts
16.5 %	Fruit and Vegetables: Oranges, apples, grapes, sweet potatoes, carrots, beets, broccoli, kale
16.5 %	Pine Nuts
33.0 %	Seed Mixture: Sunflower seeds (70%), nutritionally complete manufactured diet (15%), dehydrated whole corn (10%), cuttlebone (5%)
33.0 %	*Kaytee Rainbow chunky breeder pellets* (placed in separate bowl)

6.6.2 Denver Zoo Palm Cockatoo diet (pair)

1/3 cup	sunflower seed mix
3/4 cup	safflower seed mix
½ cup	*Scenic Jungle pellets*
½ cup	chopped assorted fruits
1/4	pomegranate
2	Purina monkey chow biscuits
1 tbsp	pinion nuts (when in season)/mixed nuts

6.6.3 Sea World of Florida

Morning:	array of available fresh fruits and vegetables and a couple of Zupreem monkey chow biscuits
Afternoon:	*Mazuri diet* and a couple of nuts (Brazil, almond or peanut)

6.6.4 Riverbanks Zoo

percent contribution to total diet by weight, as fed	
75%	Zupreem pellets
25%	Produce & seeds
	Necton MSA sprinkled over diet. (Mineral/vit. supplement)

6.6.5 White Oak Conservation Center

1 cup	*Kaytee breeder*
1 cup	chopped assorted fruits/vegetables - bananas, apples, oranges, grapes, corn, greens, carrots
1 tsp	petamine (vitamin/mineral supplement)
5-6 large nuts	given three times per week - walnut, Brazil nut, hazel nut, kamani nut, almond
1 tbsp	pinion nuts given three times per week

Table 1. Selected nutrient composition of food items commonly used in captive Palm Cockatoo diets.

Nuts/Seeds[1]		*Peanuts*	*Pine nuts*	*Walnuts*	*Pumpkin seed*	*Safflower Seed*	*Sunflower seed*
	Water (%)	6.6	2.7	2.8	6.9	5.6	5.4
On dry matter basis							
Estimated energy	kJ/100g	-	2950	2962	-	-	-
Crude Fat	%	52.7	70.5	70.5	49.2	40.7	52.4
Crude Protein	%	27.5	14.4	15.1	26.4	17.1	24.1
Calcium	%	0.06	0.01	0.10	0.05	0.08	0.12
Phosphorus	%	0.41	0.67	0.39	1.26	0.68	0.75

[1]All values are for kernel only.

Beans/Pulses[2]		*Chick Pea**	*Green bean*	*Mung Bean**	*Soya Bean**
	Water (%)	10	90.7	11	8.5
On dry matter basis					
Estimated energy	kJ/100g	1490	1079	1310	1690
Crude Fat	%	6.0	5.4	1.2	20.3
Crude Protein	%	23.7	20.4	26.9	39.3
Calcium	%	0.18	0.39	0.1	0.26
Phosphorus	%	0.34	0.41	0.4	0.72

[2]Feeds marked (*) are dried.

Fruits[3]		*Apple*	*Banana*	*Grape*	*Orange*	*Pear*	*Pomegranate*
	Water (%)	98.5	75.1	81.8	86.1	83.8	80.1
On dry matter basis							
Estimated energy	kJ/100g	1268	1598	1071	1113	1033	1495
Crude Fat	%	0.6	1.2	0.4	0.7	0.6	1.58
Crude Protein	%	2.6	4.8	1.8	7.9	5.0	1.9
Calcium	%	0.03	0.02	0.05	0.34	0.07	0.02
Phosphorus	%	0.07	0.11	0.08	0.15	0.08	0.04

[3]All values are for flesh only, not peel.

Vegetables		*Beets*	*Broccoli*	*Carrot*	*Celery*	*Pepper (capsicum)*	*Yams*
	Water (%)	87.1	88.2	88.8	95.1	90.4	67.2
On dry matter basis							
Estimated energy	kJ/100g	1167	1172	1435	598	1398	1456
Crude Fat	%	0.8	7.6	2.9	4.1	4.2	0.9
Crude Protein	%	13.2	37.3	5.9	10.2	10.4	4.6
Calcium	%	0.16	0.47	0.25	0.87	0.08	0.05
Phosphorus	%	0.40	0.74	0.15	0.43	0.23	0.08

Source: McCance and Widdowson's The Composition of Foods (6th Edition), Royal Society of Chemistry, 2002.

Table 2. Selected nutrient composition of manufactured parrot diets, compared with recommendations for extruded diets. Inclusion of commercial diets in this table is not an endorsement of specific products, but for information only and accurate at time of preparation [September 2005].

Company			***Kaytee*** *(www.kaytee.com)*	***Mazuri*** [(2)]	***Nutrazu*** *(www.nutrazu.com)*		***Versele-Laga*** *(www.versele-laga.com)*	
Product name		**Psittacine pellet**[1]	**Exact Parrot Rainbow**	**Parrot**	**Parrot, maintenance**	**Parrot, breeder**	**Nutribird 15**	**Nutribird 19**
Crude Fibre	%		5	2.2	3	3.2	4.5	4.5
Crude Fat	%		6	9.2	7	7.5	16	16
Crude Protein	%	24.00	15	21.4	16	20	15	19
Vit A	IU A/g	8.00		0.17	12	9	12	15
Vit E	mg/kg	250.00		320	185	125	30	50
Calcium	%	1.10		2.1	0.85	1.2	0.9	0.9
Iron	mg/kg	150		106	120	260	85	85
Magnesium	%	0.15		0.26	0.17	0.17	0.15	0.17
Phosphorus	%	0.80		1	0.73	0.85	0.6	0.6
Potassium	%	0.70		0.75	0.59	0.61	-	-
Selenium	mg/kg	0.30		0.06	0.27	0.27	0.30	0.30
Sodium	%	0.20		0.42	0.12	0.13	0.20	0.20
Zinc	mg/kg	120		177	102	105	100	100

[1]Formulation recommended by Ullrey *et al.* (1991), based on studies feeding psittacines other than Palm Cockatoos, inclusion of a manufactured diet meeting this nutrient profile of at least 50% of the total diet by weight as offered should meet the nutrient requirements of Palm Cockatoos but no definitive trials have been done with this species. [2]Mazuri Zoo Foods, PO Box 705, Witham, Essex, CM8 3AD, UK.

Chapter 7
Medical Management of the Adult Palm Cockatoo

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[Appended note for EEP manual: Where possible brand names, which may be USA specific, have been replaced with generic names]

Health and medical management are important to long term care and successful reproduction of Palm Cockatoos. Preventative medicine with avian species is still in its infancy, but great strides have been made in the treatment of many diseases. Husbandry and diet are the basis of any preventative medical protocol for psittacines. However, there is a need for continued research in these two areas.

7.1 Life Span

The life span of Palm Cockatoos is unknown. Most of the birds listed in the SSP studbook are wild caught birds acquired as adults. There are several birds that are known to be at least 30 years old or more, based on their length of time in captivity.

7.2 Annual Examinations

Physical examinations can be a major key in detecting disease in a species where signs of illness are hidden based on the survival instinct. Annual physical examinations during the non-breeding season serve as opportunities to identify, monitor, and document any problems or potential problems. Basic exams include parameters such as: weight, feather condition, colour of mucus membranes, locomotion, and respiratory function. Weight loss, despite a good appetite, may point to hidden disease. On the other hand, sometimes an increase in weight may be a sign of other diseases. Palpation of the keel muscle and the appearance of the feet can be good guides if taking accurate weights is not feasible

7.3 Sexing Techniques

In some cases, male Palm Cockatoos may have a larger body size and head structure than hens, but this is not an accurate method of gender determination. DNA sexing methods are non-invasive, accurate, quick, and safe. Only a breast feather or a small amount of blood is required. Blood may be collected via toe nail clip or venipuncture. Stress to the bird is greatly minimised with this technology. Chicks may be DNA sexed using blood at any age, and using feathers once true feathers have erupted. Samples for sexing are taken when the chick is banded at ABRC.

7.4 Behavioral Manifestations of Illness

Symptoms associated with avian illness include: loss of appetite, depression, weakness, droopy wings, change in faeces or urates, fluffed appearance, and tail bobbing. Since most of the symptoms are common to a number of diseases, clinical impression and testing methods must be used to determine the best course of treatment. Keeper observations and intimate knowledge of individual attitudes and appetites are important.

Poor facial colour may be a sign of illness but some Palm Cockatoos always have paler facial colour. The facial patches may turn pale or deepen to a dark reddish-purple colour when the birds are stressed, such as during capture, but usually turn bright red again after the bird has been released. Palm Cockatoos appear very stoic; they often do not struggle when held, making it difficult to gauge the amount of stress an individual bird experiences during capture. A change in facial colour not associated with stress can be considered a potential problem and the bird should be monitored or worked up for disease if additional symptoms are present.

7.5 Medical Testing Procedures

Medical testing procedures are very valuable tools. All newly acquired birds should be screened for infectious disease during the quarantine period. At ABRC, each newly acquired bird is quarantined for 90 days. Quarantine periods of Palm Cockatoos reported in the European husbandry survey ranged from three weeks (if tests negative) to seven weeks, with most being between three to four weeks. A complete physical examination is performed at ABRC, consisting of: blood chemistries, a Complete Blood Count (CBC), a cloacal culture, screening for parasites, and quarantine entry weight. Blood samples are taken for PFBD and Chlamidophilla testing, and for DNA sexing if necessary. A routine barium radiograph is taken shortly before the end of the quarantine period for a base study. Opinions concerning a bird's health status should not be made based on the results of one test. Assess all available test results and the clinical appearance of the individual.

7.5.1 Parasitology

Newly acquired birds should be screened carefully for parasites using direct and fecal float tests for intestinal parasites, blood film exam for blood parasites, and physical exam for ecto-parasites, paying particular attention to the inner wing web area. Palm Cockatoos should be screened for intestinal parasites on at least a yearly basis. It is advisable to screen birds housed with access to an earth floor more often. Previous parasitic infection and treatment may indicate the need for additional periodic screenings for an individual bird. Patients presented for weight loss, diarrhoea, and poor feather condition should be screened for parasites.

7.5.2 Blood Chemistries

Blood chemistries can be helpful in assessing the bird for infections, intestinal problems, organ function, and many diseases. ABRC has performed a study to establish blood chemistry normals for the Palm Cockatoo (Table 1). Samples were collected from a total of 41 clinically normal adult Palm Cockatoos, including 23 males and 18 females. Six birds bled for the study were captive-reared (five were hatched in 1989 and one in 1990), and 35 were wild-caught adults. Blood chemistry results for the six captive-reared birds were similar to those of the older, wild-caught birds. Slight elevations in calcium, phosphorus, uric acid, and LDH were noted in some of the younger birds, although the

individual results did fall within 2 SD of the mean level for an adult of the species. Samples could not be processed for all birds for all values.

Table 1. Blood chemistry values for adult Palm Cockatoos. Samples were collected at ABRC in November and December of 1993. Range: ± 1 standard deviation from the mean.

Test/Units	Mean and Range	# of Birds Sampled
Packed cell volume (%)	mean: 50 range: 46.5 - 53.5	n = 37
Total solids (g/dl) (refractometer)	mean: 4.2 range: 3.7 - 4.7	n = 36
Albumin (g/dl)	mean: 1.3 range: 1.1 - 1.5	n = 40
Alkaline phosphatase (IU)	mean: 77 range: 54 - 100	n = 37
Alanine aminotransferase (IU)	mean: 6 range: 2 - 10	n = 28
Aspartate aminotransferase (IU)	mean: 39 range: 26 - 52	n = 36
Calcium (mg/dl)	mean: 10.3 range: 9.6 - 11	n = 40
Cholesterol (mg/dl)	mean: 109.2 range: 95 - 123.9	n = 32
Creatine kinase (IU)	mean: 46 range: 18 - 74	n = 35
Globulin (g/dl)	mean: 2.40 range: 2.22 - 2.58	n = 39
Glucose (mg/dl)	mean: 311.3 range: 282.6 - 340	n = 39
Lactate dehydrogenase (IU)	mean: 353 range: 261 - 445	n = 39
Inorganic phosphate (mg/dl)	mean: 5.06 range: 3.37 - 6.75	n = 39
Total protein (g/dl)	mean: 3.7 range: 3.37 - 4.03	n = 39
Uric acid (mg/dl)	mean: 10.2 range: 7.7 - 12.7	n = 39

7.5.3 Haematology

Identification of white blood cells is a matter of debate among many avian health professionals. Results vary from laboratory to laboratory. It is important that in an individual laboratory, all

personnel processing CBCs are of the same opinion concerning the identification of various white cells. This ensures consistent results that, combined with the patient's appearance and other test results, will be of use to the veterinarian. Clinically normal Palm Cockatoos often have white counts on the low side of what is considered to be normal for other psittacines. However, until additional research has been performed, we should continue to work with established normals. Serial CBCs performed during the treatment of illness may be helpful in the assessment of recovery.

7.5.4 Microbiology

Prompt and accurate identification of pathogenic bacteria is often critical in cases of illness or injury. Gram stains of fecal smears may confirm the presence of Gram negative bacteria, which commonly cause illness in birds, but obtaining cultures is a better method of identifying species of bacteria. In addition, antibiotic sensitivity testing may be performed on bacteria grown from cultures to determine which drugs will have the greatest effect on the bacteria. Cultures and sensitivities are performed at ABRC prior to selection of antibiotics, except in critical cases requiring immediate treatment. Gram stains are performed for further clarification in some instances, but are felt to be somewhat inaccurate when performed as a single testing method. At ABRC, *Escherichia coli* is the most commonly isolated Gram negative bacteria species cultured from clinically normal adult Palm Cockatoos (Table 2).

Table 2: Bacteria species isolated from clinically normal adult Palm Cockatoos during routine cloacal cultures taken in 1993

Culture Site - Cloaca n = 20

SPECIES	# ISOLATED	ISOLATION RATE (%)
Escherichia coli	16	80
Klebsiella sp.	2	10
Enterobacter sp.	1	5
Non-fermentative gram negative bacilli	3	15
Staphylococcus sp.	6	30
Streptococcus sp.	8	40
Lactobacillus sp.	3	15
Corynebacterium sp.	2	10
Bacillus sp.	0	0

Crop and cloacal cultures should be taken in most cases of illness. Swabs of the pharynx or the choana may be easier to obtain than a crop culture if working with an uncooperative adult bird. A tracheal swab may be indicated if the bird suffers from respiratory problems. These cultures should be plated to media that supports mycotic growth since yeast and fungus are problems for some Palm Cockatoos. Cultures should also be performed on wounds prior to administering treatment, if possible.

It is not uncommon for cultures taken from clinically normal Palm Cockatoos to grow some Gram negative bacteria. If the percentage is small and treatment is not indicated, it may be useful to take serial cultures at intervals to assess the status of the individual. Cultures of clinically normal adults are also useful because they provide a picture of the floral content of a group of birds and can be

compared to cultures taken from sick birds. Gram positive bacteria found in the intestinal tract are usually considered normal flora; however, some may be problems in individual cases. In evaluating the bacteria grown, it is important to keep in mind the case and the site of the culture.

7.5.5 Radiology

Radiology is useful when treating skeletal, respiratory, or intestinal diseases. It can be used to make a diagnosis and to monitor recovery. Two views of any body part are recommended. Birds are much easier to radiograph when maintained under anesthesia; there is less chance of injury and the quality of the radiographs is enhanced.

Barium series can be done to outline the digestive tract and also to make distinctions between other organs. Double contrast studies, using barium and air, can reveal a blockage, although foreign body impaction has not been seen in Palm Cockatoos at ABRC. Diatrizoate sodium – diatrizoate megumine may be used if it is desirable to highlight the kidneys. The bird should be fasted and water withheld for at least 12 hours prior to taking barium radiographs. Lactated Ringers Solution may be given subcutaneously the evening prior to or directly after the procedure, if needed. Ten to 15 ml of barium sulfate can be administered into the crop using a gavage needle or feeding tube. Radiographs taken at approximately 30 minutes post administration of barium normally provide a good overview of the digestive tract. Remember that it is important to keep the bird's head elevated during administration of anesthesia, and until the bird has recovered, to prevent aspiration of the barium.

7.5.6 Additional Tests

Two other tests that have been helpful are bile acid tests for diagnosis of liver disease and thyroid levels, such as T4, if deficiencies are suspected.

7.6 Major Disease Problems and Treatments

7.6.1 Fungal Infections

In general, adult Palm Cockatoos have proven to be very hardy birds but the species is susceptible to many of the same diseases that affect other psittacines. The most common disease problems seen in Palm Cockatoos are fungal infections, and the most common fungi isolated are *Aspergillus sp*. Treatment often requires long-term therapy.

Fungal lesions have been seen in the syrinx, air sacs, lungs, base of the heart, and in major vessels. Auscultation, radiographs, haematology, blood chemistries, cultures, and endoscopy can be used to obtain a diagnosis. Treatment may include oral doses of flucytosine or fluconazole surgical removal of lesions, and intratracheal or intravenous injections of amphotemicin. Possible anaphylactic reactions were suspected in two Palm Cockatoos that died following intravenous injections of amphotemicin. No other cause of death, including fungal infection, could be determined based on necropsy and histopathology.

7.6.2 Protozoal Infections

Infections are often acute, and the birds are usually found dead with no previous signs of illness. Yellow urates, depression, and respiratory disease may be seen prior to death. Treatments include

oral doses of pyrimethamine and sulfa drugs. Formulating an antemortem diagnosis is difficult if not impossible, and it is unclear if this treatment regimen is effective. The cage mate of a bird that has died of protozoal infection may be a candidate for treatment, however it is common to have only one of a pair succumb to this disease. Gross necropsy findings typically include: very enlarged spleen, yellow fluid in the cardiac sac, and fluid-filled lungs. A quick diagnosis can be made from microscopic examination of impression smears of the lungs that have been stained using the Diff-Quik method. Sarcocystis may be diagnosed if extracellular merozoites are present.

7.6.3 Bacterial Infections

Bacterial infections occur in most psittacines and the Palm Cockatoo is no exception. Symptoms often involve the respiratory or intestinal systems. Diagnosis can be made through the use of microbiology, haematology, chemistries, and radiology. Supportive care measures include: tube feeding, diet change, and subcutaneous or intravenous fluid therapy. Some antibiotics and glucose/fluid therapies are of great value when treating the critically ill patient. Antibiotics are easily administered intramuscularly, though tissue trauma can be devastating. ABRC staff members prefer to use the subcutaneous route for this reason. Oral administration of antibiotics may be difficult when working with older or uncooperative birds.

7.6.4 Psittacine Feather and Beak Disease (PFBD)

PFBD infection has been observed in Palm Cockatoos. Currently, there is no cure for this contagious and terminal disease, but research into the development of a vaccine is ongoing. It is possible for infected birds to live a long time with supportive care but they are susceptible to bacterial and fungal infections. A DNA probe has been developed to detect the disease prior to expression of any clinical symptoms. At this time, all birds in a collection should be tested and any birds determined to be positive based on the guidelines of testing should be removed from a psittacine collection. Young birds are particularly susceptible to this and other viruses.

7.6.5 Kidney Diseases

Polyuria, polydipsia, and white crystals visible under the skin are some of the symptoms of visceral gout and kidney disease. Treatments include supportive care, antibiotics, oral allopurinol, and intravenous flushing of the kidneys. The actual cause of kidney disease is usually difficult to determine so it must be treated based on symptoms. Serum uric acid levels can be used to detect kidney problems and to monitor progress during treatment. Dehydration may cause an increase in uric acid levels; levels may return to normal after the bird has been rehydrated.

7.6.6 Feather Problems

Feather cysts occur in primary feathers of the wings and tail. In many cases the cause of feather cyst development is unknown. Chronic feather cyst development may require the permanent solution of complete follicle removal. Feather plucking or chewing is not common in wild-caught Palm Cockatoo but has been seen in several domestically raised, hand-fed birds. These individuals pluck coverts from the chest area, leaving the down intact.

7.7 Common Injuries and Treatments.

Many injuries to captive psittacines are prevented by providing safe, well-maintained housing and by ensuring that individual leg bands are closed bands, appropriately sized, and sturdy. Two types of injury that are more difficult to prevent are self-trauma and mate-trauma.

7.7.1 Mate-trauma

The most frequently treated injury of Palm Cockatoos at ABRC involves the beak; mate-trauma is the primary cause of accidental trauma, capture can also damage the beak. The maxilla of the Palm Cockatoo features a thin horny layer and soft center, factors that make beak injuries common.

Bite wounds in mate traumas occur mainly to beak, mouth, and facial area. However, the feet, legs, tail, back area, neck, and wings should also be examined. Scratches may be seen on the facial patches and chest area. Wounds range from minor scratches to severe, even sometimes fatal, injuries. Wing and beak trims and possible beak ball application to the male may prevent the mate trauma.

Minor beak injuries may heal well after they have been cleaned. Large or deep beak wounds can be cleaned and patched with acrylic. The patch not only protects the wound from infection but also adds stability. Patients with severe beak injury may require supportive care with fluids and tube feeding, and administration of antibiotics and antifungals. Mate trauma cases should be assessed for evidence of shock which could result in death if not treated. Dexamethasone sodium phosphate and prednisolore sodium succinate can be used for shock, along with heat and oxygen therapy. Puncture wounds to the mouth and commissures can be cleaned and ointments applied or sutured if needed. Birds with beak and mouth injuries should be removed from heat therapy as soon as possible as the warm environment could encourage secondary bacterial or fungal infections. Patients should be assessed for hypoglycemia, since some trauma victims have been deprived of food by their mates.

One Palm Cockatoo at ABRC lost her entire maxilla to mate trauma, leaving her sinuses exposed. The area was kept clean, and antibiotic therapy and tube feedings were administered until the area granulated in. Extreme changes had to be made in the bird's diet as she would never crack seed or nuts again. She is able to eat ground parrot pellets and ground monkey chow, and she enjoys soft fruits and vegetables.

7.7.2 Overgrown bills

Overgrown maxillas and mandibles are not unusual in Palm Cockatoos, chronically overgrown bills was reported by 6 of the 17 respondents in the European husbandry survey. Uneven beak wear is often noticeable, especially along the occlusal or biting surfaces of the maxilla and mandible, usually occurring on both surfaces. Treatment involves periodic trimming. The bird's appetite should be monitored after a major trim has been required. Previous beak injuries may result in overgrowth. Bill overgrowth problems do need to be addressed, as they may lead to dietary problems that could affect overall health (King, 2000a).

Toe and toenail injuries are less common, but do occur. If indicated, the wound should be cleaned and bandaged, and antibiotic therapy may be initiated. Cases of frostbite in Palm Cockatoos have resulted in toe mutilation. If the injury is severe, amputation of toenails or complete toes may be necessary.

7.8 Anaesthesia

Inhalant anaesthetics, e.g. Isoflurane gas, are considered the safest for Palm Cockatoos. A mask (cone) induction is the best approach, and the bird may be maintained in the mask or intubated. Palm Cockatoos at ABRC, are induced at 5%, with oxygen at a flow rate of 1.5 - 2%. The Isoflurane is dropped to 2.5% - 3.5% after induction, as required. Intubated patients can be maintained at 2 - 3% Isoflurane with oxygen flow rate at 0.8 - 1%. Prior to and during a procedure, the bird's condition should be monitored carefully. It has also been pointed out that Palm Cockatoos are sensitive to anaesthetics from the cyclohexamine family of drugs. It has been reported that some European zoos feel the appropriate dose is approximately ½ the normal dosage of cyclohexamin. (King, 2000a)

7.9 Vaccinations

At this time no proven effective vaccines are available for diseases that occur in psittacine species.

7.10 Post-mortem and Histopathology

A complete post-mortem should be performed on each bird and tissues should be submitted for histopathology. Post-mortem examination is an important tool, especially when infectious disease is suspected in a group. All organs should be examined. Tissues routinely cultured at necropsy include: heart, blood, liver, lung, spleen, and kidney. Bacterial growth from tissue cultures may be enhanced by placing the swab into an enrichment medium, such as thioglycollate, for 24 hours prior to plating onto prepared media. It is strongly recommended that the MedARKS post mortem form be used during performance of post mortem examinations, and that a copy of the completed report be sent to the EEP Coordinator.

See:
Appendix 5, Drug Information for Drug Dosages
Appendix 6, Routine Physical Exam Form
Appendix 7, Microbiology Worksheet
Appendix 9, Haematology/Chemistry/Serology Records from ISIS and WOCC

Chapter VIII
Hand-rearing and Medical Care of Young Palm Cockatoos

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8.1 *Introduction*

Palm Cockatoo chicks have been hand-raised in four of the facilities that responded to the 1992 survey. The following ideas are based on those replies and experiences at ABRC.

The hand-rearing process can be a labor-intensive undertaking. Initially, problems arose from lack of information about the species. Chicks were assisted from the egg because their incubation time was longer than that of other cockatoo species. Palm Cockatoo chicks are prone to digestive disorders and much time has been spent in the development of diets, husbandry techniques, and medical management to resolve this common problem.

As more chicks are hand-reared, more knowledge about their specific needs is gained. This improved technology has been conducive to the successful rearing of Palm Cockatoo chicks in nursery settings, should this be necessary when parents are for some reason unable to rear the young themselves.

8.2 *Husbandry*

Care and husbandry of the Palm Cockatoo chick in the nursery is similar to that of other cockatoo species. Plastic bowls, tubs, and wire cages are used for housing, depending on the age of the chicks. Paper towels, cloth towels, rubber mesh, pelleted bedding, and wire have all been used as flooring substrates. Brooders of several varieties, including human isolettes, have been used. Cleaning and disinfection procedures are the same as those used with other psittacines.

Due to the lack of first down and the length of time for feather growth in Palm Cockatoo chicks, it is important to keep them in a warm environment longer than other cockatoo species. Temperatures at day one begin at 35°C to 37.5°C and are gradually decreased as the chick grows. They are kept in brooders or warm rooms (about 29°C) until they are fully feathered. Digestion and skin colour may be directly related to environmental temperature.

Chicks receive their first feed when they are visibly dry post-hatching (see feeding schedule table). This first feeding can be either Pedialyte or diluted formula. Feeding intervals are the same as for other cockatoo species. A diluted formula is fed for the first three days and then switched to the regular formula. Feeding amounts are increased and intervals decreased as the chick grows. This is based on the individual chick and the diet being used. Syringe feeding is the most popular and easiest method of hand-feeding. Formula should be fed at 41.5°C. Microwaved food must be stirred thoroughly to ensure that there are no hot spots. Catheter tipped syringes, with or without a soft rubber tip, can be used. Palm Cockatoo chicks have a vigorous and eager feeding response.

Numerous diets have been used to successfully raise Palm Cockatoos, with the birds exhibiting no growth or digestive problems. Their specific nutritional requirements are unknown, but in the last few years fewer problems have been seen. Formulas that have been used successfully are: Monkey Chow based formulas, ABRC's Palm Cockatoo Formula, Kaytee Exact Macaw Formula, Prettybird 19/12 Formula, Lakes hand-feeding Formula, and Kaytee Exact Macaw Formula with added ingredients. Regardless of the diet used, recording daily weights is a good way to monitor a chick's development.

8.3 *Hand-rearing Diets*

8.3.1 ABRC (since 1997)
70 g Kaytee Exact Macaw Hand-rearing Diet
20 g sunflower seed (hulled)
40 g apple (fresh)
40 g broccoli (green)
230 g water

Everything is blended together and fed as described above. The first couple days the chicks receive diluted Kaytee Exact Macaw Hand-rearing Diet only and then the rest of the formula is slowly added. After using this diet, ABRC has seen an improvement in the condition of their chicks. (Updated by Mike Taylor from phone conversations with Sharon Wolf)

8.3.2 Riverbanks Zoo
hand-raised two Palm Cockatoo chicks in 1996 and one in 1997. They used the Kaytee Exact Original Formula for the first couple months, then changed to the macaw formula when they finished their supply of the original formula. They gave the first chick peanut oil and mycostatin to prevent Candida. They felt sufficiently confident that they decided to rear the second chick entirely on the Kaytee formula. They experienced no growth or other medical problems. The only problem they experienced was when they tried to wean the second chick, of 1996, along the same timeline as the first and it was not ready to wean (see weaning section of this chapter). Even with both chicks in the same pen, the second chick refused to eat completely on its own.

8.3.3 Saint Catherine's Island Survival Center
Saint Catherine's Island Survival Center also hand-raised two Palm Cockatoo chicks in 1996. They used Pretty Bird 19/12 formula with their two chicks. They did not experience any growth or other medical problems such as the gout problem experienced by ABRC. The only change to the basic diet was the addition of a small amount of peanut oil to the diet when the chicks started feathering. They started this when they noticed the first chick's feathers did not look right.

8.4 *Feeding Schedule*

The feeding schedule for Palm Cockatoo chicks raised at ABRC is provided in Table 1. However, decisions concerning a chick's progress are made on an individual basis. This information is offered

only as a guideline.

Table 1. Feeding schedule for Palm Cockatoo chicks raised at ABRC

AGE (DAYS)	ROOM TEMP	FEEDING SCHEDULE	COMMENT
1	35°C	Begin with 0.2ml. Increase amount 0.2ml at each feeding, until bird is receiving 1ml per feed. Bird receives 10 feedings day 1. First feeding 5:00 A.M., last feeding 9:00 P.M.	Example: 0.2ml, 0.4ml, 0.6ml, 0.8ml, then 1ml at each feeding for the rest of the day.
2	35°C	1ml at each feeding. Bird receives 10 feedings day 2. First feeding 5:00 A.M., last feeding 9:00 P.M.	
3	35°C	1.5ml x 6 feedings. First feeding 5:00 A.M., last 9:00 P.M.	
4	35°C	2ml x 4 feedings. First feeding 6:00 A.M., last 9:00 P.M.	
5 - 14	33 - 35°C	Continue to feed 4 times daily. First feeding 6:00 A.M., last feeding 6:00 P.M. Begin to increase amount fed daily. Increase a total of 2ml per day divided by 4 feedings (0.5ml increase/feeding) for *aterrimus*. If the bird is digesting well after several days on this schedule, this may be changed to an increase of 4 ml per day, divided by 4 feedings, as described below. Increase a total of 4 ml per day divided by 4 feedings (1 ml increase/feeding) for Goliaths	Example for an *aterrimus* chick: Day 5: 2.5ml x 4 feeds Day 6: 3ml x 4 feeds Day 7: 3.5ml x 4 feeds Day 8: 4ml x 4 feeds Day 9: 4.5ml x 4 feeds, etc.
15 (approx.)	29.5 - 32°C	*Aterrimus* chicks 3 times a day feeding schedule. First feeding 6:00 A.M., last feeding 9:00 P.M. Begin to increase the amount from 1 - 5ml daily divided between 3 feedings, according to the needs of the individual chick. Goliaths remain at the above schedule.	Example: Day 15: 7.5ml x 3 feeds. Day 16: 8.5ml x 3 feeds. Day 17: 9.5ml x 3 feeds Day 18: 11ml x 3 feeds…
30 (approx.)	29.5 - 32°C	Goliath chicks begin 3 times a day feeding schedule. First feeding 6:00 A.M., last feeding 9:00 P.M. Begin to increase the amount from 1 - 5ml daily divided by 3 feedings, according to the needs of the individual chick.	
50 - 60	27°C	Begin to offer bread sticks, almond toast, monkey chow, peanuts, and other foods to encourage independent feeding. *Aterrimus* chicks 2 times a day feeding schedule. First feeding 6:00 A.M., last feeding 4:00 P.M. Goliaths stay at 3 times a day. First feeding 6:00 A.M., last feeding 9:00 P.M.	Formula should be fed at 40.5°C. Microwaved formula may contain hot spots & must be stirred thoroughly before feeding
60 - 70	27°C	Goliath chicks 2 times a day feeding schedule. First feeding 6:00 A.M., last feeding 4:00 P.M.	Use a separate syringe for each bird
100 - 120	27°C	*Aterrimus* chicks 1 time a day feeding schedule. First feeding 6:00 A.M. Goliaths stay at 2 times a day. First feeding 6:00 A.M., last feeding 4:00 P.M.	Make fresh formula, or defrost cubes, for each feeding. Do not reheat or reuse formula.
110 - 150	27°C	Goliath chicks begin 1 time a day feeding schedule. First feeding 6:00 A.M.	

8.5 *Development, Fledging and Weaning*

Features in physical development and growth are found in Table 2.

Parent-reared chicks have left the nest between 57-110 days, but are fed by the parents for

several months thereafter (King, 2000a; Low, 1993). There is no hard, set rule regarding weaning times of hand-reared chicks. Each bird should be treated as an individual. Careful weight monitoring of hand-reared birds is critical at this period; care must be taken to ensure that the bird does not become malnourished due to low caloric intake. A bird that is receiving formula once a day and digesting well should not be rushed into complete independence. Some chicks will wean completely at five months, weaning usually occurs at 6-7 months, but others may take up to a year if they have had health problems.

Hand-reared Palm Cockatoo chicks usually start picking at food around the age of 60 days. The types of food offered are very important. Bread sticks, almond toast, dry monkey chow, pine nuts, and peanuts are good foods to start with. After independent eating begins, this menu is expanded to include a sunflower based seed mix and a variety of fruits and vegetables. Placing an already self-feeding chick in an enclosure with a weaning chick may stimulate self-feeding- but can also lead to free meals, as a 1.5 year old Palm Cockatoo at Rotterdam Zoo was observed feeding a begging chick in the weaning process.

Table 2. Physical Development and Growth Characteristics

AGE (in days)	**CHARACTERISTICS**
Hatch	No down feathers
Hatch	Ears open
Hatch	Beak, tongue, body, foot, and nail pigment are absent
14-18	Eyes open
21-118	Crest feather development
21-91	down feather development (body)
21	Bright red facial colour and blushing
21	Tips of nails turning black
25-154	Secondary feather development
25	Red skin pigment
28-61	Primary feather development
36-161	Tail feather development
40-50	Black pigmentary striations on beak
41-91	Flank down development
43-105	Skin develops black pigment
62	Tongue tip begins to turn grey
110	Toenails completely black
140	Tongue deep red with black lips
161	Total feather maturity
29 months	Beak completely black (*P.a.aterrimus*)
32 months	Beak black with white tip (*P.a. goliath*)

8.6 *Behavioral Manifestations of Illness in Chicks*

Palm Cockatoo chicks have unique characteristics, some of which are not medical in basis. They start stamping their feet as early as two weeks. Head shaking, often considered a serious problem, is actually quite normal in development. When approached with food, Palm Cockatoos are quite

vocal, attempting to pump on anything available. Facial colour is quite variable within the first few weeks, though a strong facial flush is typical. Pale facial colour, sleepiness, and constant crying are behaviors that may be associated with illness.

8.7 ***Neonatal Examinations***

It is ideal to handle chicks when their crops are at least half empty. Even then, care should be taken not to tip the chick on his back, causing it to aspirate. Musculoskeletal corrections such as taping, splinting, and body suits, should be applied when a chick's crop is almost empty, and the chick housed in a deep, padded, snug container. Palm Cockatoos rarely require these types of corrections.

First appraise musculoskeletal symmetry, skin colour, and hydration. Also note how the chick sleeps, its position, and whether it is content. The chick's weight and size should be comparable with others of the same age and species. Keeping a daily weight record is an excellent way of monitoring a chick's growth.

Starting at the beak, check for deviations of the maxilla to the right or left, and whether there is narrowing or extra growth on either side of the mandible. When the chick closes its beak, the upper should hook over the lower. Beak deviations are rarely seen in Palm Cockatoo chicks.

Opening a chick's mouth is relatively easy compared to an adult's. Smell the breath since many species have distinct odors. Check the choana, glottis, salivary consistency, and oral cavity. The glottis of a Palm Cockatoo is quite deep-seated, predisposing it to easy aspiration.

The eyes of Palm Cockatoo chicks open at 14 to 18 days. The eyelids open slowly, usually slightly above and caudal to the eyes. The lids then develop and move over the eyes. Problem chicks may develop more slowly, though surgical intervention has not been necessary. If the eyes are open, examine as with any other animal.

While in the area of the eye, gently palpate and examine the sinus eye ring. Swellings can be indicative of sinus or respiratory problems. The nares and ears should be clean, non-inflamed, and patent. Head shaking behavior is a normal developmental stage for Palm Cockatoo chicks, although it may signify sinus or ear problems in other species.

Begin the spinal examination by palpating the neck and noting the position in which it is held. A primary neck problem often results in other, compensatory problems, such as wing, beak, and leg deviations. Follow the spinal cord from head to tail, then gently tip the chick over, checking the symmetry of the sternum and pelvis. Palm Cockatoo chicks rarely have spinal cord deformities.

The half-empty crop should be examined for over-all colour. Look for hemorrhages, vascular congestion, and oedema. Compare the crop size to that of other chicks, checking for stretched, non-functional crops, especially in previously sick chicks. Waves of motility can often be seen in the crop of a healthy chick. Food retention, leading to a stretched crop, is very common in Palm Cockatoos. Slow digestion can be a subtle indicator of hidden problems. At ABRC, it is not unusual to see an inflammation of the skin over the crop in weaning birds, especially those housed outdoors.

This may be related to heat or to insects and resolves without treatment.

The "umbilical" area can be the key to many problems. The area should be sealed off in newly hatched chicks, the skin is often constricted at the site. There may be a dried up tag of tissue attached that usually falls off in two to three days. Fleshy protuberances can be a nidus of infection and need to be tied off and cleaned. This occurs mainly with problem hatches.

It is common to see the absorbed yolk sac underneath the umbilical cord. This should disappear in four to five days. Other organs can be visualized as well, including: the liver edge, the intestinal loops, the ventriculus, and the accumulation of subcutaneous and intestinal fat. This area is a wonderful window to monitor progression or deterioration.

Examine the inside of the cloaca with a cotton swab for the degree of hydration, colour of the mucus membranes, and the presence of faeces. Note the amount, colour, and consistency of faeces. Scant faeces is often an indicator of dehydration and other problems.

When examining wings, legs, and feet, always look for symmetry. Buckled wings detected early can be easily corrected. Wing tip hemorrhages may be early indications of trauma or infections. With cases of leg and feet deviations, palpate up to the femoral head to determine where the deviation starts. Check the toes for plumpness. Constrictions can lead to sloughing of whole digits.

Feather development may be retarded in previously sick chicks. Poor development of down feathers can be an early indicator of infection which may surface later. The flank down is slow to mature. The pin feathers (blood feathers) should be examined for hemorrhage, loose follicles, constrictions, and stress lines. Chicks exert a large amount of energy in feather production, making this a very sensitive, stressful time. As the birds feather out, the environmental temperature should be reduced.

Finally, re-examine the condition of the chick's container. Individual, snug-fitting, deep containers with a towel covering part of the top provide a nest-like environment. As the chicks get larger, they can have more room to explore. Monitoring temperature changes in the nursery from day to night may prevent a variety of problems.

8.8 *Major Disease Problems and Treatments*

The most frequently observed manifestation of illness in a hand-reared Palm Cockatoo chick is failure to digest. Many years have been spent trying to devise the right diet and methods to enhance digestion through feeding management and medical treatment, with more success in recent years. Hand-reared Palm Cockatoo chicks are most vulnerable to digestive problems a few days after hatch, at around two months of age, and at weaning. At these critical periods management, as well as medical parameters, should be evaluated. Always assess brooder temperature and intervals of feeding. Problems related to temperature of the environment, formula temperature, feeding amounts, and intervals between feeding are the most common causes of digestive disorders. Cultures should be taken, though bacterial infections are not always the cause.

It is ideal for most neonate psittacines to have an empty crop after the overnight fast. However, residual food between feedings and in the morning is common in hand-reared Palm Cockatoos. This amount varies according to the size of the bird, quantity of food, and the number of times fed. In weaning chicks, residual food is usually less than 5 ml. A possible cause for this is the Palm Cockatoo chick's apparent ability to regurgitate from the proventriculus back into the crop. Care must be taken with assessing the caloric intake of a growing bird. Any chick that is not obtaining enough nutrition to grow will deplete body resources for nutrients.

If digestive problems are exhibited, evaluate hydration. Dehydrated chicks of any age may benefit greatly from subcutaneous fluid therapy. Well-hydrated chicks show improved digestion. A single bolus of subcutaneous fluids, such as Lactated Ringers, is sometimes all that is needed. The preferred site for administering subcutaneous fluids is the inside of the thigh, pointing toward the inguinal area.

Crop bras are an excellent adjunct to other digestive therapies, but are most effective when applied to older chicks. Because Palm Cockatoos are prone to aspiration, it may be helpful to remove the crop bra while feeding the bird.

Digestive problems in chicks from pinfeather to weaning can be grouped together. It is a common mistake to feed diluted food, more times a day, reducing the calorie intake. A better solution may be the reverse - feeding full strength formula, increasing the amount, and increasing the interval of time between - total caloric intake remaining the same. Crops which fail to empty, can be emptied via feeding tube. Care must be taken when attempting this procedure so as not to damage the crop wall. Fresh formula can then be fed.

Weaning chicks that have free access to water may appear to be retaining formula, but the real problem may be over-consumption of water. If this is suspected, a simple preliminary approach is to remove access to food and water for 24 hours, leaving the bird with access only to syringe fed food.

In some cases, digestive problems are the result of bacterial and fungal infections. These microorganisms proliferate in warm, humid environments, common in psittacine nurseries. Gastrointestinal infections are best assessed by cloacal cultures. It is accepted that many normal chicks will grow low levels of Gram negative bacteria, species varying by nursery. Flora from crop cultures is often directly related to the bacterial content of hand-feeding formula. It is common to culture yeast from a Palm Cockatoo chick's crop. Because this is a common cause of digestive problems in Palm Cockatoos, birds are treated after yeast is cultured, even if they appear clinically normal. At ABRC, we treat with mycostatin, ketoconazole, or a combination of the two. Vitamin C may be a potential treatment for control of low grade yeast infections. Antibiotics, if indicated, are easy to administer orally to chicks because of the feeding response. Chicks with crop stasis should receive antibiotics subcutaneously or intramuscularly until digestion is returned to normal. The subcutaneous route is preferred in chicks with little keel muscle to prevent inflammation to the muscle. Chicks being treated with antibiotics are given mycostatin concurrently.

CBCs and blood chemistries can be used to screen for infections and to evaluate a chick's organ function and nutritional status. While these tests usually require a larger amount of blood than can be obtained from a debilitated chick, a toenail clip can yield a sample sufficient for a PCV, total

solids, and a WBC estimate. Specific normals for CBC and blood chemistries for Palm Cockatoo chicks have not been established at this time. ABRC staff members refer to the normals established for other cockatoo species.

If not properly addressed, maldigestion typically leads to malnutrition. In addition to other parameters, it is crucial to monitor the patient's uric acid, calcium, and albumin levels. Uric acid typically increases while the calcium and albumin decline. Uricemia (uric acid in the blood) is a better terminology than kidney failure because we are not sure whether this is pre-renal or renal. In the seriously compromised patient, an intravenous catheter can be placed into the jugular to give direct access to the venous (circulatory) system, facilitating transfusions, parenteral nutrition, antibiotic therapies, and the administration of metaclopramide to enhance digestion. Metaclopramide may be administered subcutaneously if an intravenous catheter has not been placed.

8.9 ***Neonate Mortality***

With advancements in husbandry, diet and pediatric medicine, mortality in Palm Cockatoo chicks is relatively low. In cases of death, necropsy techniques are the same as those used on adult birds. However, special attention should be applied to lymphoid organs, *i.e.* bursa and thymus. These organs, the original basis of the immune system, involute with age and are invaluable in assessing the bird's immune status. Tissues are routinely submitted for histopathology. If the situation warrants, tissues may be frozen.

See:
Appendix 5, Drug Information for drug dosages
Appendix 6, Routine Physical Exam Form
Appendix 7 Microbiology Worksheet
Appendix 8, Growth Charts from ABRC
Appendix 9, Haematology Values for Juvenile Cockatoos from ABRC
Appendix 10, Haematology/Chemistry/Serology Records from ISIS and WOCC
Appendix 11, Hand-reared Palm Cockatoo Chick Weights from ABRC
Appendix 12, SSP Post-mortem and Histopathology Techniques/Recommendations

Palm Cockatoo chicks raised at Riverbanks Zoo
Hatched 1996

Riverbanks Zoological Park raised two chicks in 1996. They had no problems with the first chick. The second chick did not want to wean, but it turned out fine. They used a commercial diet - Kaytee Exact Macaw Hand Rearing Formula.

Day 1-2
36.8 °C and 80% RH (we left the chick in the Grumbach for several days).
1 part Kaytee Exact: 6 parts lactated ringers, fed every 2 hours from 08:00-22:00.
A probiotic was added to the food (Lacto Plus) and mycostatin was used to prevent *Candida* overgrowth; dose in ml's = body weight / 400 BID. With the second chick, we decided not to use the mycostatin. There have been no problems and we continue to clean the mouth religiously after feeds.

Day 3-4
Dilution of food varied from 3:1 to 4:1, depending on rate of digestion. Feed interval increased to about 3 hours.

Day 5-onwards
Feed interval increased to 4-5 hours. We were not completely happy with the rate of digestion; on the advice of ABRC we started adding peanut oil to the Kaytee diet of the first chick. The oil made up 10% of the whole formula. The second chick did not have peanut oil added and seemed to grow as normally as the first chick. Liquid feeds of lacted ringers were also given between main feeds, which significantly improved the rate of digestion/crop motility without affecting weight-gain.

Day 47
2 feeds per day of up to 75ml. Bird kept at room temperature.

Day 60
Starting to pick at food items.

Kaytee Exact
Crude protein (min) 22%
Crude fat (min) 8%
Crude fiber (max) 5%
Moisture (max) 10%

Weight gains of two chicks raised in 1996.

Age/Day	1	2	3	4	5	6	7	8	9	10	11
First	17.95	21.1	18.0	20.7	21.3	24.5	27.7	33.3	37.2	45.5	48.6
Second	18.9	21.4	24.3	27.8	31.4	36.6	41.9	43.4	52.9	61.4	69.1

Age/Day	12	13	14	15	16	17	18	19	20	21	22
First	56.5	65.3	76.9	83.3	88.2	101.3	114.0	121.5	135.9	149.2	150.0
Second	75.5	81.1	89.2	101.2	110.9	122.8	135.1	140.0	151.0	174.9	176.0

Age/Day	23	24	25	26	27	28	29	30	31	32	33
First	169.4	177.7	193.4	214.5	233.1	256.3	269.3	289.7	300.3	314.5	323.6
Second	192.2	214.1	231.3	238.0	247.4	259.4	275.6	293.0	312.7	336.7	354.9

Age/Day	34	5wk	6wk	7wk	8wk	9wk	10wk	11wk	12wk	27wk	32wk
First	339.2	353.2	461.5	501.0	555.0	598.8	544.4	510.0	515.0		528.0
Second	368.7	390.4	463.4	504.5	532.7	615.7	627.1		655.0	570.0	

Palm Cockatoo chicks raised at St. Catherine's Island Survival Center Hatched 1996

St. Catherine's Island Survival Center raised two chicks in 1996 without any problems on PrettyBird 19/12 Hand-rearing Formula. The only change to the basic diet was the addition of a small amount of peanut oil to the diet when the chicks started feathering.

This is a general guide. Please use your judgment as the chick develops.

Age	Exp. Weight	Brooder Temp.	Pretty Bird formula/H2O	Amt. Fed per Feeding	Feeding Schedule
Hatch	16g (20g) (goliath wts)	35 - 37.2 °C	1:5	0.1 - 0.2 ml	6 hrs after hatch
1	17g (22g)		1:4	0.3 ml work up to 1.0 ml	every 2 hrs w/ a 4 hr
2	18g (23g)		1:4	1.0 - 1.3 ml	break 2-6 am
3	20g (24g)		1:3.5	1.5 - 1.75 ml	
4	21g (27g)	35 °C	1:3.5		
5	24g (29g)		1:3	2.0 - 2.5 ml	every 3 hrs
6	27g (33g)		1:3		6 am to
7	30g (36g)		1:3	3.0 - 3.5 ml	midnight
week 2 8 to 14	32g (40g) 60g (73g)	33.3 - 35 °C	1:2.5	Inc. amt. daily by 0.5 to 1.0 ml	every 4 hours
week 3 15 to 21	66g (80g) 102g (121g)		1:2.5		
week 4 22 to 28	153g (194g)		1:2.5		
week 5 29 to 35	208g (271g)	30 – 32.2 °C when pin feathers emerge	1:2.5	Increase amount daily by 1.5-2.5 ml	every 6 hours
week 6 36 to 42	260g (338g)		1:2.5		
week 7 43 to 49	310g (370g)		1:2.5		
week 8 50 to 56	349g (410g)		2:3 adult diet		every 8 hours
week 9 57 to 63	389g (438g)		2:3 adult diet		
week 10 64 to 70	399g (489g)		2:3 adult diet		
week 11 71 to 77	417g (508g)		2:3 adult diet		
week 12 78 to 84	428g (544g)		2:3 adult diet		
week 13 85 to 91	443g (577g)		2:3 adult diet		
week 14 92 to 98	450g (577g)		2:3 adult diet		
week 17 119 to 125	450g (580g)		weaned		12 hours (BID)

Appendix 1
IUCN 2006 Red List Species Information

The IUCN Red List of Threatened Species™ Species Information

Probosciger aterrimus

Summary | Distribution | Other Documentation | References | **Comprehensive**

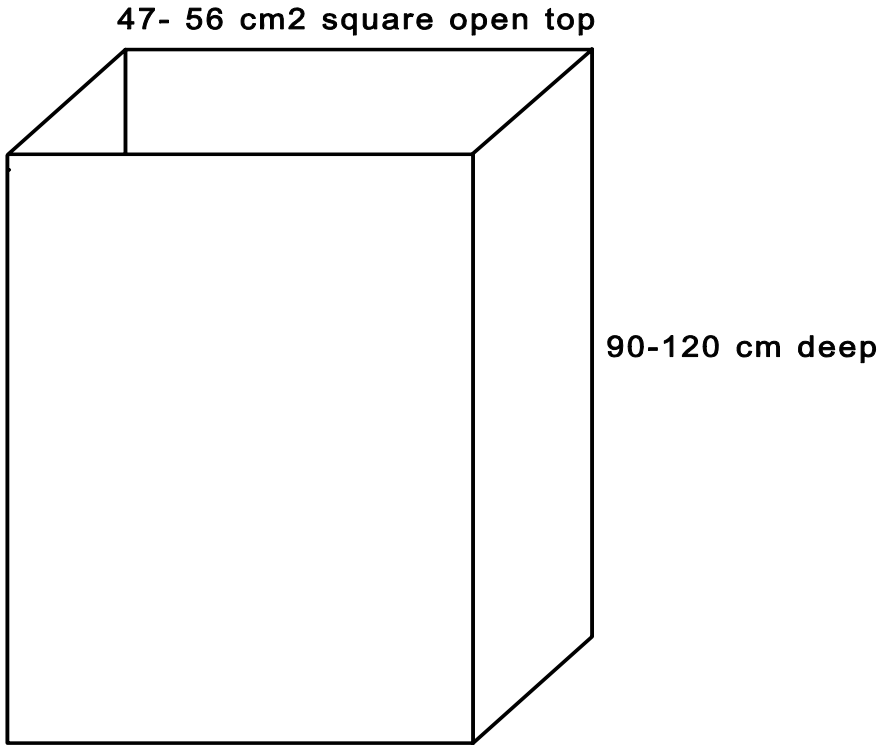
Taxonomy	
Kingdom	ANIMALIA
Phylum	CHORDATA
Class	AVES
Order	PSITTACIFORMES
Family	PSITTACIDAE
Common Name/s	PALM COCKATOO (E) CACATOÈS NOIR (F) MICROGLOSSE NOIR (F) CACATÚA ENLUTADA (S)
Species Authority	(Gmelin, 1788)
Assessment Information	
Red List Category & Criteria	LC ver 3.1 (2001)
Year Assessed	2004
Assessor/s	BirdLife International
Evaluator/s	Ekstrom, J. & Butchart, S. (BirdLife International Red List Authority)
Justification	*Probosciger aterrimus* is found in Australia and New Guinea (Indonesia and Papua New Guinea), and has a large range, with an estimated global extent of occurrence of 100,000¿1,000,000 km². In Australia, subspecies *macgillivrayi* is confined to the northern Cape York Peninsula, from Pormpuraaw on the west coast to Princess Charlotte Bay on the east. It is believed to have a stable population of *ca*. 3,000 individuals. In some parts of its range, the woodland habitat in which hollow trees occur is being invaded by rainforest. The fire which maintains the rainforest/woodland ecotone also has the potential to reduce hollow availability if managed incorrectly, particularly where rainforest is stable or contracting (Garnett and Crowley 2000). In New Guinea, it is widespread and tolerant of degraded forest

	habitats, mostly in the lowlands and foothills but occasionally up to 1,350 m. The species is still recorded relatively commonly and appears to have a large overall population, but it is believed to be in decline primarily due to hunting, but also through habitat loss (Coates 1985, Eastwood 1996b, Mack 1998, Richards and Rowland 1995, T. Leary in litt. 2000). The global population size has not been quantified, but the species is not believed to approach the thresholds for the population size criterion of the IUCN Red List (i.e., less than 10,000 mature individuals in conjunction with appropriate decline rates and subpopulation qualifiers). Global population trends have not been quantified; there is evidence of a population decline (del Hoyo *et al*. 1997), but the species is not believed to approach the thresholds for the population decline criterion of the IUCN Red List (i.e., declining more than 30% in ten years or three generations). For these reasons, the species is evaluated as Least Concern.
History	1988 - Lower Risk/least concern (BirdLife International 2004) 1994 - Lower Risk/near threatened (Collar, Crosby and Stattersfield 1994) 2000 - Lower Risk/least concern (BirdLife International 2000)
Distribution	
Country Names	Australia Indonesia Papua New Guinea
Summary Documentation	
System	Terrestrial
Major Habitat/s (terms)	1.6 Forest - Subtropical/Tropical Moist
Detailed Documentation	
Range	*Prosobsciger aterrimus* is found in **Australia** and New Guinea (**Indonesia** and **Papua New Guinea**), and has a large range, with an estimated global Extent of Occurrence of 100,000-1,000,000 km. In Australia, subspecies *macgillivrayi* is confined to the northern Cape York Peninsula, from Pormpuraaw on the west coast to Princess Charlotte Bay on the east. It is believed to have a stable population of c.3,000 individuals. In some parts of its range, the woodland habitat in which hollow trees occur is being invaded by rainforest. The fire which maintains the rainforest/woodland ecotone also has the potential to reduce hollow availability if managed incorrectly, particularly where rainforest is stable or contracting (Garnett and Crowley 2000). In New Guinea, it is widespread and tolerant of degraded forest habitats, mostly in the lowlands and foothills but occasionally up to 1,350 m. The species is still recorded relatively commonly and appears to have a large overall population, but it is believed to be in decline primarily due to hunting, but also through

	habitat loss (Coates 1985, Eastwood 1996b, Mack 1998, Richards and Rowland 1995, T. Leary *in litt.* 2000). The global population size has not been quantified, but the species is not believed to approach the thresholds for the population size criterion of the IUCN Red List (i.e. less than 10,000 mature individuals in conjunction with appropriate decline rates and subpopulation qualifiers). Global population trends have not been quantified; there is evidence of a population decline (del Hoyo *et al*. 1997), but the species is not believed to approach the thresholds for the population decline criterion of the IUCN Red List (i.e. declining more than 30% in ten years or three generations). For these reasons, the species is evaluated as Least Concern.
Data Sources	
Data Sources	Baillie, J. and Groombridge, B. (compilers and editors) 1996. *1996 IUCN Red List of Threatened Animals*. IUCN, Gland, Switzerland. Bird Reference Citations. The numbers inserted in the text accounts above (usually in bold) refer to references. For further details on these references, click on the BirdLife International link above to go to the specific species account on the BirdLife web site. In some cases, particularly in the taxonomic notes, the references are cited using the author names. Details for these can be found on the BirdLife International web site at the following two places: **For References from A–L**. **For References from M–Z**. BirdLife International. 2000. *Threatened Birds of the World*. Lynx Edicions and BirdLife International, Barcelona, Spain and Cambridge, U.K. BirdLife International. 2004 *Threatened Birds of the World 2004*. CD-ROM. BirdLife International, Cambridge, U.K. Collar, N.J., Crosby, M.J. and Stattersfield, A.J. 1994. *Birds to Watch 2. The World List of Threatened Birds* BirdLife International. Page Bros (Norwich) Ltd, U.K.

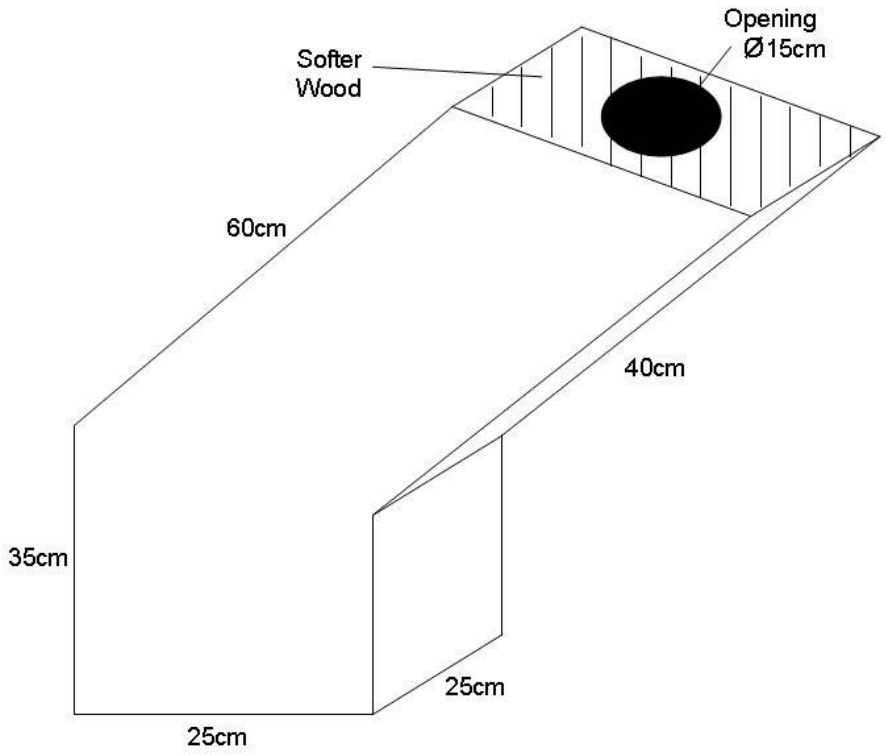
Appendix 2
Nest Box Examples

Open Top Style



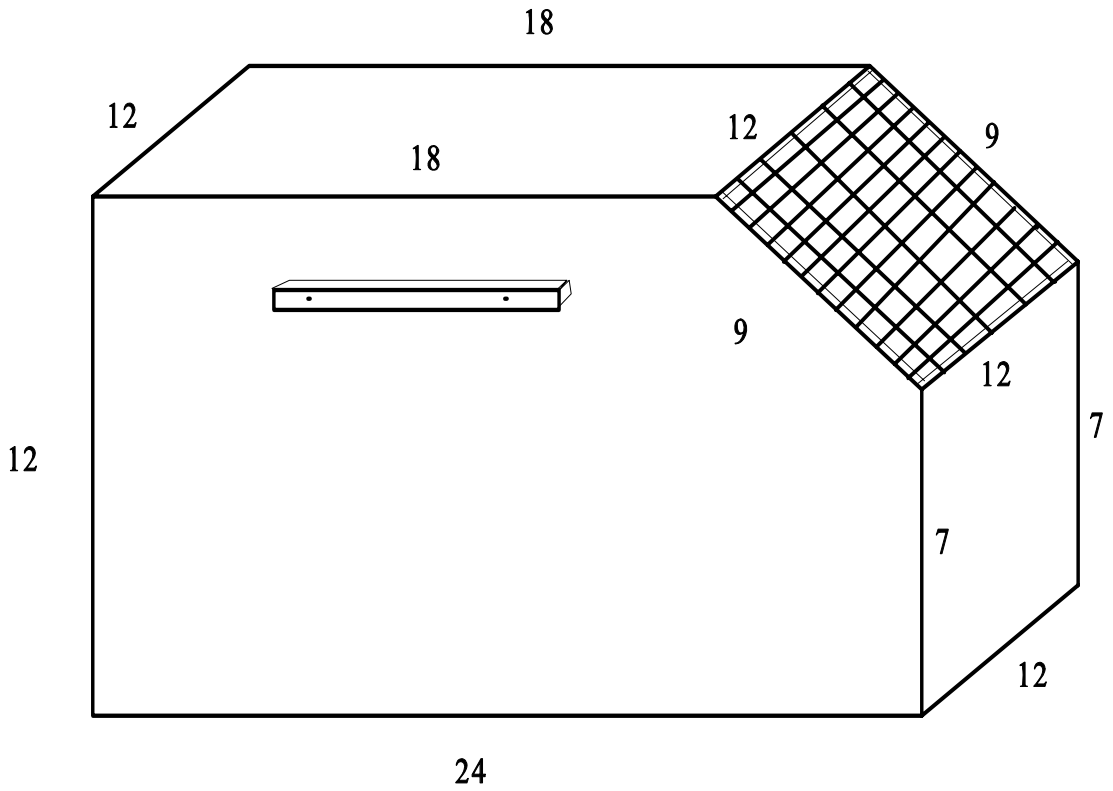
Open top boxes can be made with 2-2.5 cm plywood or, if a particular pair tends to chew the plywood too much, similar sized hardwood planks can be used. There should be at least two feet of clearance above the box to allow the birds to comfortably perch on the edges. This allows the birds to drop the splinters, which make up their nesting material, into the box.

Palm Cockatoo nest box used at the Rotterdam Zoo



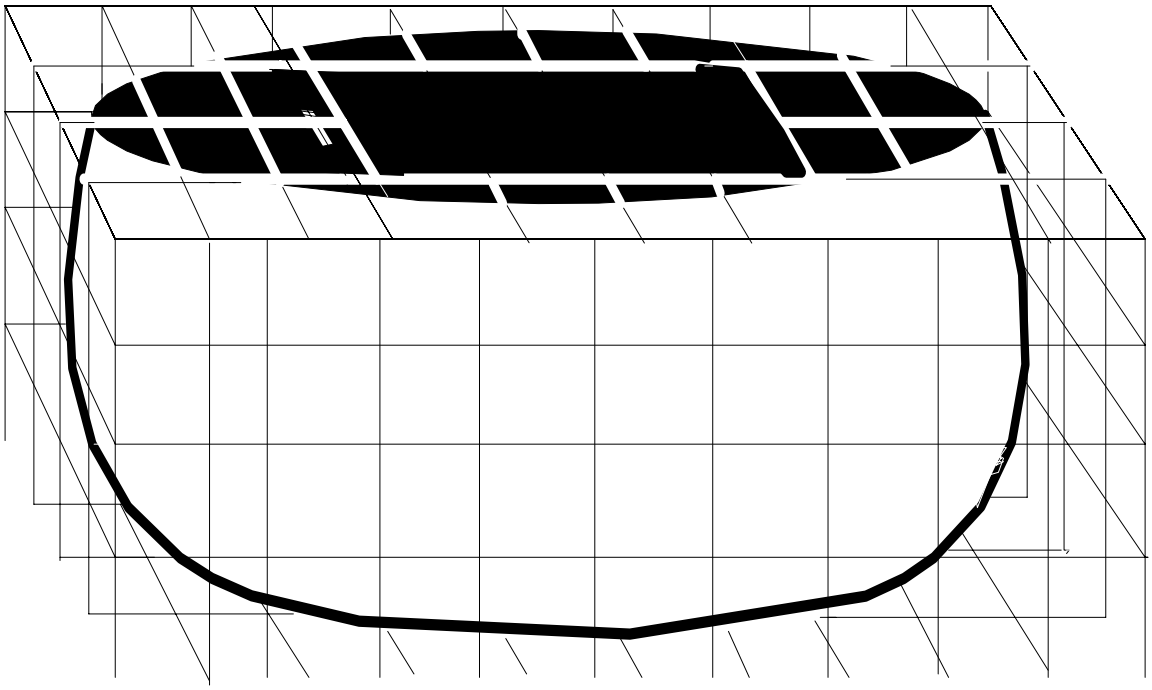
This slanted entrance nest box is constructed from "Trespa", an extremely hard material formed from layers of paper pressed together under extremely high pressure. The nest boxes have very wide openings over which replaceable entrances of much softer wood of the appropriate thickness is mounted. The wood used for the Palm Cockatoos is at least 2 cm thick. (King, C., pers. comm.)

Appendix 3
Shipping Crate used by ABRC



Dimensions in inches

Appendix 4



Basket Diagram

As mentioned in the text, the wire basket has a hole in the top allowing the birds to reach into the bowl. This design prevents the birds from tipping their bowl over. The wire basket can be made out of 1" x 1" welded wire and "J clips" and can be attached to the side of the pen. A small access door on the outside of the pen allows the bowl to be placed into the basket.

Appendix 5
Drug Information

Antibiotics

DRUG	MANUFACTURER	CONCENTRATION	DOSE	ROUTE	DOSING	COMMENT
AMIGLYDE V (Amikacin)	**Aveco**	**250 mg/ml**	**10 - 15 mg/kg**	**IM**	**BID, TID**	**Patient must be well hydrated. May cause nephrotoxicity Broad spectrum.**
BAYTRIL (Enrofloxacin)	**Miles**	**22.7 mg/ml**	**15 - 20 mg/kg *5mg/kg**	**PO, IM, SQ**	**BID**	**Can be irritating to muscle. Broad spectrum**
CEFA-DROPS (Cefadroxil)	**Aveco**	**50 mg/ml**	**100 mg/kg**	**PO**	**BID, TID**	**Broad-spectrum with low toxicity. Store up to 2 weeks in refrigerator.**
CLAFORAN (Cefotaxime)	**Hoechst-Roussel**	**300 mg/ml**	**100 mg/kg *75-100 mg/kg**	**IM**	**TID, QID**	**Broad spectrum with low toxicity. Store up to 10 days in refrigerator.**
DOXYCYCLINE (Vibramycin monohydrate)	**Pfizer**	**5 mg/ml**	**25 mg/kg**	**PO**	**SID, BID**	**For *Chlamydia***
PIPERACIL (Piperacillin)	**Lederle**	**400 mg/ml**	**200 mg/kg *100-200mg/kg**	**IM**	**BID, TID**	**Broad spectrum with low toxicity. Store up to 7 days in refrigerator.**
TMS (Trimethoprim w/ Sulfamethoxazole)	**Rugby**	**8 mg/ml**	**16 - 24 mg/kg *8mg/kg**	**PO**	**BID, TID**	**Can cause vomiting. Limited spectrum**

Antifungals

DRUG	MANUFACTURER	CONCENTRATION	DOSE	ROUTE	DOSING	COMMENT
ANCOBON (Flucytosine)	Roche	125 mg/ml	250 mg/kg *20-50mg/kg *50-250mg/ kg of feed	PO	BID for 21 days	1 capsule/ 4 ml H2O/KY jelly mixture For Aspergillosis and candidiasis Toxic to bone marrow.
DIFLUCAN (Fluconazole)	Roerig	5 mg/ml	4 mg/kg *2-5 mg/kg	PO	SID	For Aspergillosis and candidiasis. May cause regurgitation.
FUNGIZONE (Amphoteracin B)	Squibb	5 mg/ml	1 - 1.5 mg/kg	IV, IT	BID for 3 days	For Aspergillosis. Store up to 7 days in refrigerator. Nephrotoxic.
NIZORAL (Ketoconazole)	Janssen	5 mg/ml	20 mg/kg *20-30 mg/kg	PO	BID	1/4 tablet in 10 ml Gatorade H2O. For Candidiasis. Works upon absorption.
NYSTATIN (Mycostatin)	Rugby	100,000 units/ml	1 ml/ 300 gm	PO	BID, TID	0.33 per 100 gm Not absorbed - works on contact.

Miscellaneous

DRUG	MANUFACTURER	CONCENTRATION	DOSE	ROUTE	DOSING	COMMENT
ALLOPURINOL	Geneva	100 mg/tablet	1 ml/ 400 gm	PO	BID	Xanthine oxidase inhibitor. For treatment of uricemia.
AMINOPHYLLINE	Elkins Sinn	25 mg/ml	10 mg/kg	IM, IV, SQ	as needed	Broncodialator.
BANAMINE (Flunixin)	Schering-Plough	50 mg/ml	5 mg/kg *1-10 mg/kg	IM	BID, TID	Analgesic and anti-inflammatory. Antipyretic.
DARAPRIM (Pyrimethamine)	Burroughs Wellcome	25 mg/tablet	0.5 mg/kg	PO	BID for 2 - 4 days, then ½ dose for 30 days	1 tablet/ 10 ml H2O/KY jelly mixture. For Sarcocystis.
DEX SP (Dexamethasone sodium phosphate)	Burns	4 mg/ml	0.1 ml/ 100 gm	IM, IV	as needed	For treatment of shock, trauma, and certain inflammations.
FUROSEMIDE	Burns	50 mg/ml	0.5 mg/ 300 gm *0.15-2 mg/kg	IM	BID	0.0016 mg/gm for Sarcocystis. Diuretic
REGLAN (Metoclopramide hydrochloride)	A. H. Robins	5 mg/ml	0.2 - 0.4 mg/kg *0.5 mg/kg	IM, IV, SQ	TID, QID	For stimulating gastrointestinal motility.
VITAMIN C (Sodium Ascorbate)	Burns	250 mg/ml	250 mg/lb *20-40 mg/kg	PO	BID	For yeast control. (experimental)
VITAMIN K (Phytonadione)	Bimeda	10 mg/ml	2 mg/kg *0.2-2.5 mg/kg	IM	as needed	Involved in blood clotting.

Anthelmintics

DRUG	MANUFACTURER	CONCENTRATION	DOSE	ROUTE	DOSING	COMMENT
DRONCIT (Praziquantel)	Haver	23 mg/tablet	0.1 ml/ 350 gm *10-20 mg/kg *9 mg/kg	PO	once, repeat in 10 - 14 days	For tapeworms.
IVOMEC (Ivermectin)	Merck	10 mg/ml	20 ug/kg *200 ug/kg	IM	once, repeat in 10 - 14 days	For some nematodes, coccidia, mites, and lice
PANACUR (Fenbendazole)	Hoechst-Roussel	suspension	30 mg/kg *20-50 mg/kg	PO	SID for 3 days	For ascarids, capillaria, microfilaria and flukes.
NEMEX II (Pyrantel panoate)	Pfizer	4.5 mg/ml	4.5 mg/kg	PO	once, repeat in 10 - 14 days	For intestinal nematodes.

Appendix 6
Routine Physical Exam Form

Date:_____ Species:_____ Bird ID#:_____

Location:_____ Weight:_____

Head/beak region:

Eye exam:_____

Maxilla & mandible:_____

Oral cavity:_____

Nostrils:_____

Ears:_____

General feather condition:_____

_____

Muscle/ Weight condition:_____

Respiratory System:_____

Cardiac System:_____

Wings:_____

Body:_____

Legs:_____

Feet/ Toes:_____

Abdomen:_____

Cloaca/Vent Area:_____

Appendix 7
Microbiology Worksheet

Date: _____ **Reason For Culture: _____**

Species: _____ **Bird #: _____** **Band/Trans #: _____**

Name: _____ **Egg #: _____** **Cage #:_____**

Lab #: _____ Source: _____ **Lab: _____ Source: _____**

TSA Amount: _____

Gram +	Gram -
1.	1.
2.	2.
3.	3.
4.	4.
%_____	%_____

TSA Amount: _____

Gram +	Gram -
1.	1.
2.	2.
3.	3.
4.	4.
%_____	%_____

MacConkey Amount: _____
1.
2.
3.
4.

MacConkey Amount: _____
1.
2.
3.
4.

Sab Dex Amount: _____
Gram + _____
Gram - _____
Yeast: _____
Fungus: _____

Sab Dex Amount: _____
Gram + _____
Gram - _____
Yeast: _____
Fungus: _____

EMB Amount: _____

Chocolate II: _____

Coag Test: positive negative

Isolations: _____

Gram Stains: _____

API: _____

Sensitivity: _____

EMB Amount: _____

Chocolate II: _____

Coag Test: positive negative

Isolations: _____

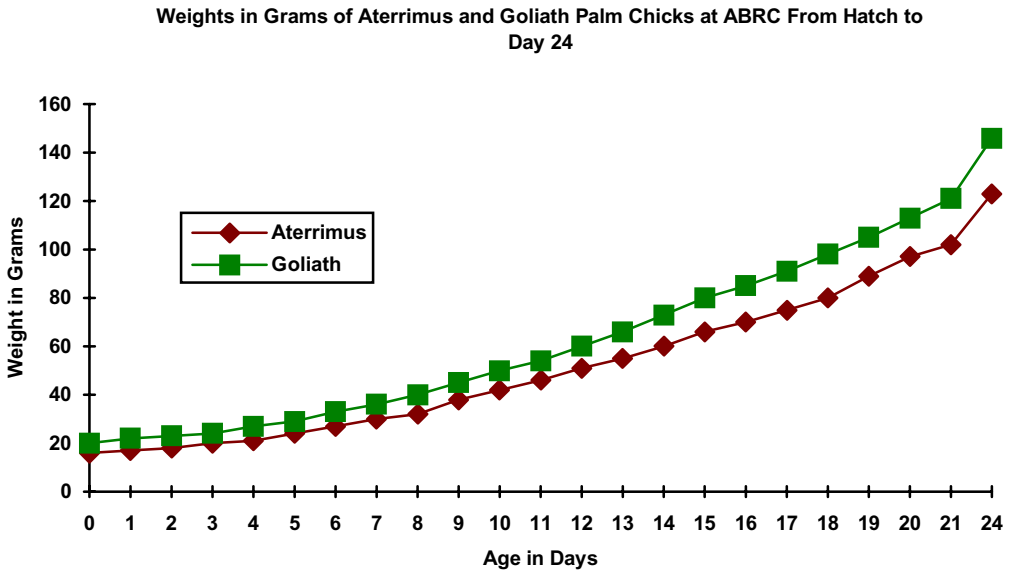
Gram Stains: _____

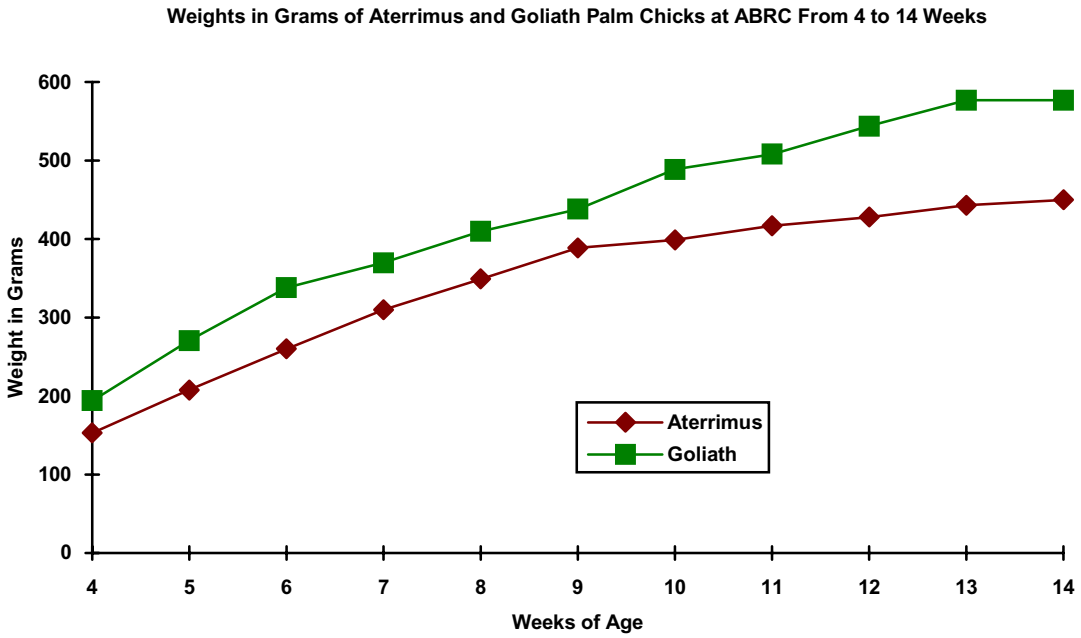
API: _____

Sensitivity: _____

Organism	PIP	ENO	CTX	STX	G	AN	C			

Appendix 8
Growth Charts





Appendix 9
Haematology Values for Juvenile Cockatoos from ABRC

Reprinted from: Schubot, R., et al. 1992. Psittacine Aviculture: Perspsectives, Techniques, and Research. Willis Printing Group, Inc. USA.

	30 day Mean (SD) Range n = 58	60 day Mean (SD) Range n = 44	90 day Mean (SD) Range n = 29	180 day Mean (SD) Range n = 21	All Mean (SD) Range n = 152
RBC #	1.96 (0.22)a	2.7 (0.22)a	2.84 (0.49)b	3.38 (0.45)c	2.53 (0.63)
(x106/ul)	1.5-2.5	2-3.6	2-4	2.-4	1.5-4
HB	8.12 (0.83)a	12.76 (1.55)b	14.04 (1.23)c	14.22 (1.00)c	11.43 (2.90)
(g/dl)	6.5-10	10-16	12-17	12-16	6.5-17
HCT	30.1 (2.8)a	44.6 (6.4)b	47.6 (4.1)c	47.2 (3.1)b,c	39.7 (9.0)
(%)	25-36	34-59	39-56	42-52	25-59
MCV	155 (17)a	167 (24)b	172 (28)b	141 (17)c	160 (23)
(fl)	130-200	120-215	130-215	120-175	120-215
MCH	3809 (11.7)a	47.9 (5.9)b	49.0 (12.9)b	42.7 (5.7)a	43.8 (10.8)
(pg)	31-50	36-60	38-65	35-55	31-65
MCHC	24.6 (7.9)a	28.8 (1.8)b	28.5 (6.2)b,c	30.1 (1.5)c	27.2 (6.1)
(g/dl)	24-33	24-33	27-33	28-33	24-33
WBC #	13700 (7400)a	13400 (6300)a	10000 (2800)b	13500 (5900)a	12900 (6300)
(cells/ul)	5500-25000	6000-25000	6000-15000	8000-25000	5500-25000
WBC Est	13200 (6700)a	13200 (5700)a	10400 (2800)b	15600 (6200)a	13100 (5900)
(cells/ul)	5000-24000	5000-24000	6000-13000	8000-25000	5000-25000
BAND	1.3 (2.3)a,b	1.8 (2.6)a	1.3 (2.3)a,b	0.3 (1.1)b	1.3 (2.3)
(%)	0-6	0-7	0-6	0-2	0-7
HET	54.8 (9.7)a	51.9 (12.5)a,b	49.0 (8.1)b	39.6 (12.2)c	50.8 (11.7)
(%)	36-74	27-77	33-65	15-64	27-74
LYMPH	36.4 (8.1)a	39.1 (11.6)a,b	43.6 (8.4)b	55.9 (13.6)c	41.2 (11.9)
(%)	20-53	16-62	27-61	29-83	17-65
MONO	6.9 (3.4)a	6.0 (3.0)a,b	4.9 (3.4)b,c	3.5 (2.8)c	5.8 (3.4)
(%)	1-12	1-12	0-12	0-9	0-12
EOS	0 (0)	0 (0)	0 (0.2)	0 (0)	0 (0)
(%)					
BASO	0.6 (0.9)a,c	1.2 (1.2)b	1.2 (1.1)b	0.9 (1.0)b,c	0.9 (1.1)
(%)	0-2	0-4	0-4	0-3	0-4
BAND #	150 (275)a	245 (420)a	130 (290)a	45 (200)a	160 (325)
(cells/ul)	0-1000	0-1200	0-1400	0-1000	0-1400
HET #	7800 (5000)a	6800 (4700)a	4400 (2200)b	5400 (4200)a,b	6500 (4500)
(cells/ul)	2200-18000	2000-17000	2800-10000	2200-13000	2000-18000
LYMPH #	4900 (2600)a	4600 (2300)a	3900 (2000)a	6800 (2900)b	4900 (2500)
(cells/ul)	1800-10000	2000-8500	2200-8000	4500-10000	1800-10000
MONO #	880 (530)a	680 (440)a	440 (450)a	500 (580)a	690 (525)
(cells/ul)	0-2000	0-1600	0-1200	0-1600	0-2000
EOS #	0(0)	0(0)	0 (0)	0 (0)	0 (0)
(cells/ul)					
BASO #	67 (130)a	140(150)a	115 (130)a	115 (145)a	100 (140)
(cells/ul)	0-500	0-500	0-500	0-500	0-500
HET:LYMPH	1.6 (0.6)a	1.6 (1.2)a,b	1.2 (0.4)b	0.8 (0.5)c	1.4 (0.8)
(ratio)	0-3	1-4	0-2	0-2	0-3
PP (Refrac)	2.3 (0.5)a	3.7 (0.6)b	4.0 (0.9)b	3.8 (0.4)b	3.2 (0.80)
(g/dl)	1-3.5	2.5-4.5	2-5	3-5	1-5

Serum Biochemical Values for Juvenile Cockatoos from ABRC

a,b,c,d: Values for parameters are statistically different (P<0.05) when letters are different.

	30 day Mean (SD) Range n = 58	60 days Mean (SD) Range n = 44	90 day Mean (SD) Range n = 29	180 day Mean (SD) Range n = 21	All Mean (SD) Range n = 152
NA (mEq/L)	139 (3)a 135-145	145 (2)b 141-150	150 (3)c 145-155	152 (3)c 145-155	145 (6) 135-155
K (mEq/L)	4.0 (0.8)a 2.5-5.5	3.3 (0.5)b 2.5-5.5	3.1 (0.4)b 2.5-4	3.6(0.5)c 3-5	3.6 (0.7) 2.5-5.5
CL (mEq/L)	105 (4)a 97-112	109 (3)b 104-115	115 (4)c 109-120	115 (4)c 110-120	110 (6) 97-120
CA (mg/dl)	9.2 (0.6)a 8-10	9.9 (0.6) b 9-11	9.5 (1.0)a,b 7-11	9.9 (1.0)b 8-11	9.6 (0.7) 8-11
PHOS (mg/dl)	7.0 (0.6)a 6-8	6.4 (0.8)b 5-8	5.1 (1.0)c 3.5-7	4.8 (1.0)b 3.5-6.5	6.1 (1.1) 3.5-8
UREA (mg/dl)	1.6 (1.9)a 0-5	2.1 (2.2)a,b 0-6	2.6 (2.5)b 0-6	2.4 (2.5)a,b 0-6	2.0 (2.2) 0-6
CREAT (mg/dl)	0.31 (0.06)a 0.3-0.5	0.37 (0.08)a,b 0.2-0.7	0.42 (0.07)a,b 0.5-0.5	0.46 (0.07)b 0.2-0.7	0.4 (0.1) 0.2-0.7
UA (mg/dl)	1.2 (0.9)a 0.2-3.2	2.7 (1.6)b 0.4-6.5	5.1 (1.8)c 2.0-8.5	4.5 (1.7)c 2.0-8.5	2.9 (2.3) 2.0-8.5
CHOL (mg/dl)	165 (32)a 100-250	320 (70)b 180-450	350 (122)b 150-500	202 (130)c 150-300	251 (105) 100-500
GLUCOSE (mg/dl)	247 (20)a 200-300	259 (21)b 200-300	249 (29)a,b 200-300	262(30)b 200-300	253 (24) 200-300
LDH (IU/L)	393 (348)a 150 - 1000	338(241)a 130-1000	367 (218)a 150-1000	386 (264)a 150-1000	371 (285) 150-1000
AST (IU/L)	98 (54)a 50-175	139 (85)b 80-250	195 (73)c 150-400	195 (66)c 120-320	143 (79) 50-400
ALT (IU/L)	2 (2)a 0-13	3 (4)b 0-13	3 (3)a,b 0-12	2 (2)a,b 0-5	2 (3) 0-13
ALP (IU/L)	593 (202)a 180-1000	714 (239)b 400-1000	478 (167)c 280-800	407 (186)c 200-850	579 (239) 200-1000
GGT (IU/L)	2.35 (1.75)a 0-6	3.00 (1.43)b 0-6	2.79 (1.54)a,c 1-5	1.81 (1.28)a,c 0-4	2.55 (1.67) 0-6
CK (IU/L)	595 (205)a 300-1000	615 (228)a 170-1000	368 (156)b 170-600	267 (161)c 140-410	510 (235) 140-1000
TP (g/dl)	2.2 (0.4)a 1.5-3	3.1 (0.5)b 1.5-4	3.1 (0.6)b 2-4	3.2 (0.6)b 2.6-4	2.8 (0.7) 1.5-4
ALB (g/dl)	0.8 (0.2)a 0.3-1.2	1.2 (0.2)b 0.6-1.5	1.2 (0.3)b 0.7-1.6	1.4 (0.3)c 1.0-1.6	1.1 (0.3) 0.3-1.6
GLOB (g/dl)	1.3 (0.4)a 1.8-1.2	1.9 (0.4)b 1.2-2.5	1.9 (0.4)b 1.5-2.5	1.8 (0.4)b 1.5-2.5	1.7 (0.5) 0.8-2.5
A:G (ratio)	0.6 (0.2)a,b 0.38-0.8	0.6(0.1)b 0.45-0.85	0.6 (0.1)b 0.5-0.85	0.8 (0.1)c 0.6-1	0.6 (0.2) 0.38-1
PRE ALB (g/dl)	0.4 (0.1)a 0.2-0.6	0.5 (0.2)b 0.2-1	0.5 (0.2)b 0.2-0.8	0.5(0.1)b 0.3-0.6	0.5(0.2) 0.2-1
ALB (Elect) (g/dl)	1.1 (0.3)a 0.5-1.8	1.7 (0.3)b 1.1-0.6	1.7 (0.5)b,c 0.2-2.3	1.9 (0.3)c 1.6-2.3	1.5 (0.5) 0.5-2.3
ALPHA GLOB (g/dl)	0.2 (0.1)a 0.1-0.3	0.2 (0.1)b 0.1-0.5	0.3 (0.2)c 0.1-0.5	0.4 (0.2)d 0.4-0.5	0.2(0.1) 0.1-0.5
BETA GLOB (g/dl)	0.3 (0.2)a 0.1-0.7	0.4 (0.2)a 0.1-0.8	0.3(0.1)a 0.2-0.5	0.3(0.1)a 0.2-0.4	0.3 (0.1) 0.1-0.8
GAMMA GLOB (g/dl)	0.2 (0.11)a 0.1-0.4	0.3 (0.1)b,c 0.2-0.8	0.3 (0.1)b 0.1-0.4	0.5 c 0.5-0.5	0.3 (0.1) 0.1-0.8

Appendix 10
Haematology/Chemistry/Serology Records Report - Reference Values for Palm Cockatoos of All Ages from ISIS and White Oak Conservation Center

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		ISIS Values			White Oak Conservation Center Values				
		Mean	S.D.	(N)	Mean	S.D.	Min.	Max.	(N)
WBC	*10^3/UL	13.06 ±	8.066	(20)	8.633 ±	3.769	2.500	16.80	(39)
RBC	*10^6/UL	3.50 ±	1.15	(44)	2.709 ±	0.928	1.500	4.360	(12)
HGB	GM/DL	14.1 ±	2.3	(32)	12.65 ±	0.61	11.90	13.20	(4)
HCT	%	42.5 ±	4.2	(72)	42.29 ±	3.96	31.00	50.00	(41)
MCH	uug	46.8 ±	21.3	(30)	57.66 ±	3.13	55.11	61.97	(4)
MCHC	g/dl	33.8 ±	4.9	(31)	31.28 ±	0.79	30.13	31.81	(4)
MCV	fl	136.5 ±	48.8	(42)	168.4 ±	50.5	100.8	266.7	(12)
Heterophils	*10^3/UL	7.060 ±	5.982	(20)	4.087 ±	2.689	1.197	12.94	(39)
Bands	*10^3/UL	0.306 ±	0.284	(3)	0.000 ±	0.000	0.000	0.000	(2)
Lymphocytes	*10^3/UL	5.267 ±	2.886	(20)	3.371 ±	2.029	0.384	9.035	(39)
Monocytes	*10^3/UL	0.008 ±	0.022	(11)	0.727 ±	0.574	0.000	2.520	(36)
Eosinophils	*10^3/UL	0.040 ±	0.033	(3)	0.216 ±	0.194	0.000	0.792	(28)
Basophils	*10^3/UL				0.130 ±	0.138	0.000	0.476	(22)
Glucose	MG/DL	306 ±	36	(42)	301.5 ±	36.0	217.0	371.0	(35)
BUN	MG/DL	4 ±	2	(32)	4.342 ±	1.775	1.000	8.000	(31)
Uric Acid	MG/DL	10.0 ±	2.9	(49)	9.306 ±	3.291	0.700	16.50	(35)
CA	MG/DL	9.0 ±	1.0	(36)	9.050 ±	0.899	7.400	10.80	(34)
PHOS	MG/DL	3.9 ±	0.9	(35)	4.103 ±	1.098	2.100	7.400	(30)
NA	MEQ/L	150 ±	4	(29)	150.6 ±	4.6	138.0	159.0	(31)
K	MEQ/L	4.8 ±	1.4	(29)	4.661 ±	1.425	3.300	8.900	(31)
Chloride	MEQ/L	116 ±	7	(30)	114.7 ±	3.3	104.0	122.0	(30)
Iron	MCG/DL	221 ±	242	(9)	141.7 ±	43.3	86.00	214.0	(11)
CHOL	MG/DL	140 ±	24	(33)	136.1 ±	22.7	77.00	174.0	(30)
TRIG	MG/DL	137 ±	45	(11)	151.6 ±	36.0	94.00	215.0	(12)
T.PROT. ©	GM/DL	3.4 ±	0.5	(50)	3.256 ±	0.333	2.400	3.800	(36)
T.PROT. (R)	GM/DL				3.100 ±	0.577	2.400	3.800	(4)
Albumin ©	GM/DL	1.2 ±	0.3	(35)	1.187 ±	0.307	0.400	1.700	(30)
Globulin ©	GM/DL	2.0 ±	0.6	(36)	2.103 ±	0.501	1.200	3.500	(31)
AST (SGOT)	IU/L	70 ±	41	(45)	62.48 ±	34.53	3.000	153.0	(34)
ALT (SGPT)	IU/L	7 ±	5	(26)	7.212 ±	5.036	0.000	18.30	(25)
T. BILI.	MG/DL	0.2 ±	0.2	(27)	0.228 ±	0.165	0.000	0.500	(29)
D. BILI	MG/DL	0.1 ±	0.0	(8)	0.082 ±	0.041	0.000	0.100	(11)
ALK.PHOS.	IU/L	64 ±	24	(32)	62.32 ±	23.83	21.00	149.0	(29)
LDH	IU/L	203 ±	155	(14)	195.2 ±	119.1	78.00	552.0	(15)
CPK	IU/L	164 ±	85	(26)	157.5 ±	86.9	65.00	411.0	(23)
A/G Ratio	GM/DL				0.388 ±	0.286	0.100	1.090	(9)
BUN/CREAT	MG/DL				13.05 ±	5.14	5.000	20.00	(6)
CO2	MMOL/L	13.2 ±	3.1	(20)	12.90 ±	3.14	8.000	20.00	(20)
CREAT.	MG/DL	0.4 ±	0.1	(8)	0.283 ±	0.039	0.200	0.300	(12)
Fibrinogen	GM/DL	108 ±	111	(13)	0.200 ±	0.141	0.100	0.400	(4)

Printed on: 24.Jul.1996 **/ISIS/MedARKS/5.13 beta**

Haematology/Chemistry/Serology Records Report - Reference Values for Palm Cockatoos of All Ages White Oak Conservation Center

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		ISIS Values			White Oak Conservation Center Values				
		Mean	S.D.	(N)	Mean	S.D.	Min	Max.	(N)
GGT	IU/L	14 ±	8	(8)	12.27 ±	7.31	3.000	31.00	(11)
HEMOCYTO.	18 /18 Squares (22)				217.0	±	80.2	74.00	415.0
Indirect Bilirubin		0.2 ±	0.1	(8)					
Osmolality	MOSMOL/KG (12)				313.3	±	14.3	276.0	329.0

Printed on: 24.Jul.1996 /ISIS/MedARKS/5.13 beta

Appendix 11
Hand-reared Palm Cockatoo (*P.a.aterrimus*) Chick Weights
(Raised at ABRC)

Age in Days	Mean Weight in Grams	Weight Range in Grams
1	17.6	16.6 - 18.6
2	18.4	17.4 - 19.4
3	20.0	19.5 - 20.5
4	21.5	20.2 - 22.8
5	23.5	22.3 - 24.7
6	25.5	23.8 - 27.2
7	29.9	28.0 - 31.8
8	35.3	31.9 - 38.7
9	41.0	37.2 - 44.8
10	45.3	41.5 - 49.1
11	49.5	45.0 - 54.0
12	55.8	50.4 - 61.2
13	62.7	57.3 - 68.1
14	67.8	61.5 - 74.1
15	77.3	70.6 - 84.0
16	84.5	77.2 - 91.8
17	93.5	86.2 - 100.8
18	103.5	96.1 - 110.9
19	111.7	104.2 - 119.2
20	118.8	110.9 - 126.7
21	128.2	119.3 - 137.1
22	139.6	129.6 - 149.6
23	152.8	144.1 - 161.5
24	162.4	153.2 - 171.6
25	173.8	162.8 - 182.8
26	184.0	174.4 - 193.6
27	193.4	181.9 - 204.9
28	204.6	193.6 - 215.6
29	219.6	202.9 - 236.3
30	233.4	218.0 - 248.4
31	248.0	233.6 - 262.4
32	260.0	246.7 - 273.3
33	270.4	257.5 - 283.3
34	283.2	268.5 - 297.9
35	293.8	280.1 - 307.5
42	358.0	333.3 - 382.7
49	443.0	418.0 - 468.0
56	482.0	422.7 - 541.3
63	519.5	427.8 - 611.2

Appendix 12

Palm Cockatoo SSP Post-mortem and Histopathology Techniques/Recommendations

Developed by John Olsen, DVM, Palm Cockatoo SSP Veterinary Advisor
and Chris Schiller, DVM, Palm Cockatoo SSP Veterinary Pathology Advisor
and approved by the Palm Cockatoo SSP Management Group

FORMALIZED TISSUE COLLECTION

Sections of tissues should be no more than 1 cm in width and should be placed in 10% buffered formalin at a ratio of one part tissue to ten parts formalin.

TISSUES TO BE SAMPLED (including any lesions, abnormalities within these or other organs):

- Skin with feather.
- Skeletal muscle - longitudinal section of thigh and pectoral muscle.
- Bone/bone marrow - femur.
- Peripheral (Sciatic) nerve.
- Thymus.
- Thyroids and parathyroids.
- Frontal sinus - cross section obtained with strong scissors.
- Trachea and syrinx.
- Lungs - section from each lung including major bronchus.
- Air sacs.
- Heart-sections including atrium, ventricle and valves from right and left heart.
- Tongue - cross section.
- Esophagus - 3 cm in length, opened longitudinally.
- Crop - 3 cm in length, opened longitudinally.
- Proventriculus - 3 cm long sections.
- Ventriculus - 3 cm long sections.
- Small intestine - multiple sections, each 3 cm in length, opened longitudinally.
- Ceaca and large intestine - multiple section, each 3 cm in length, opened longitudinally.
- Liver - multiple sections.
- Pancreas.
- Spleen - split between containers.
- Adrenal.
- Kidney - multiple sections from each kidney.
- Testis/Ovary.
- Oviduct - with longitudinal cut into lumen.
- Brain - half in formalin and half frozen

NEONATAL/EMBRYONIC TISSUE

In addition to the above tissues, the following should be sampled:

Neonate: Umbilical area and surrounding tissue.

Embryo: Fix in toto - open celomic cavity.
Egg membranes and shell

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