

Husbandry Manual for Dollarbirds

Eurystomus orientalis



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Cover photograph: Dollarbird (*Eurystomus orientalis pacificus*), courtesy of Sharyn Rosewarne.

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1. Introduction

The Dollarbird (*Eurystomus orientalis*) is a species of roller belonging to the Order Coraciiformes, which also includes the hornbills, kingfishers and bee-eaters. This order is characterized by having a large head, short neck, short legs, relatively weak feet, and usually a long and/or broad bill. The plumage is generally bright with iridescent greens and blues (Fry & Fry 1999; Witman 2007).

The rollers, so named due to their habit of rolling from side to side during territorial and courtship flight displays (Perrins 1979), belong to the Family Coraciidae. This family consists of only two genera, *Eurystomus* and *Coracias*, containing 12 species. The Dollarbird is the only representative of the Coraciidae found in Australia (Fry & Fry 1999). It is a migratory bird, arriving in October for the breeding season and departing in February to winter in the Sunda and Solomon Islands, the Bismark Archipelago and New Guinea surrounds (Frith 1976; Henderson 1999; Trounson & Trounson 1987), although Dollarbirds have been known to overwinter in northern Australia (Fry & Fry 1999).

Whilst rollers as a group are popular exhibit birds (Coraciiformes TAG 2004), Dollarbirds are not commonly kept in captivity. According to the ISIS database (2008), only 16 specimens are held in the member zoological communities worldwide. However, that number should rise with captive breeding underway at San Diego Zoo (C Hall pers. comm.).

In aviculture, there are eight species of *Coracias* rollers that are commonly kept (in particular the European, *C. garrulous*; Lilac-breasted, *C. caudata*; Indian Blue, *C. benghalensis*; and Raquet-tailed, *C. spatulata*) (Vince 1996), however no reference has been found regarding Dollarbirds being kept in private aviculture.

2. Taxonomy

2.1 NOMENCLATURE

Class:	Aves
Subclass:	Neornithes
Order:	Coraciiformes
Family:	Coraciidae
Genus :	<i>Eurystomus</i>
Species:	<i>orientalis</i>

(*Eurystomus* – Greek. wide mouthed; *orientalis* – Latin. eastern)

2.2 SUBSPECIES

There are currently 10 subspecies of *Eurystomus orientalis* recognised (Table 1). *E. orientalis pacificus* is the only subspecies to reach Australia (Higgins 1999).

Table 1. Subspecies and distribution of Dollarbirds (*Eurystomus orientalis*) (Fry 2001; Higgins 1999).

Subspecies	Distribution
<i>E. orientalis pacificus</i>	Lesser Sundas and north and east Australia, probably also south Sulawesi and Sula Island, southern population winters north to New Guinea and Wallacea
<i>E. orientalis orientalis</i>	Northeast India, Indochina, south to Greater Sundas, Philippines, winters Sulawesi and Moluccas
<i>E. orientalis laetior</i>	Southwest India
<i>E. orientalis irisi</i>	South-central Sri Lanka
<i>E. orientalis gigas</i>	South Andaman Island
<i>E. orientalis calonyx</i>	North India and Nepal to east China, southeastern Russia and Japan, winters south to South Asia and Greater Sundas
<i>E. orientalis oberholseri</i>	Simeulue Island, off northwest Sumatra
<i>E. orientalis waigiouensis</i>	New Guinea, including Karkar, Bagabag, Western Papuan Islands, Yaper, Rook, Trobriand Island, D'Entrecasteaux and Louisiade Archipelagos
<i>E. orientalis crassirostris</i>	Bismark Archipelago
<i>E. orientalis solomonensis</i>	Solomon Islands

2.3 SYNONYMS

Coracias orientalis Linnaeus, 1766

2.4 OTHER COMMON NAMES

Dollar Bird or Common Dollarbird;
Australian, Eastern, Broad-billed, Eastern Broad-billed or Red-
billed Roller; Rainbird;
Starbird.
(Frith 1976; Higgins 1999)

3. Natural History

In the wild, Dollarbirds inhabit rainforest clearings, margins of evergreen forest, wooded riverbanks, cultivated forest clearings, and cleared areas containing scattered, remnant old trees (Fry & Fry 1999). These habitats provide large open spaces which accommodate their aerial foraging and flying displays (Fry 2001). During the day, they can often be observed perched in elevated positions such as tall trees, power lines and lamp posts (Higgins 1999).

Dollarbirds are crepuscular, being largely inactive during the day, feeding mainly on a diet of insects during early morning, and late afternoon to dusk. They are sit-and-wait predators, catching insects in mid-air, a process called hawking. Once caught, the insect is either crushed and eaten whilst still in flight, or taken back to the perch to be consumed (Fry 2001).

Dollarbirds normally live either singly or in pairs (Fry & Fry 1999). However, they have been known to flock in groups of 50 or more during migration or after rain when insects are active (Higgins 1999).

While largely silent, they do have a harsh vocalization which lacks the diversity and structure that is seen in songbirds. When at perch, a “kek-kekek” can be heard, while a strident, crescendo “kek...kek...kek-kek-kek-kek-k-k-k-k” is used as a contact or territorial call (Fry 2001).

Wild Dollarbirds begin arriving in the breeding grounds in northern and eastern Australia during the spring months, usually in October, with breeding commencing shortly after arrival. Eggs are laid from November to January. Nesting generally occurs in natural tree hollows, however they have been known to nest in arboreal termite mounds. Nests are usually high above the ground (average 14.6 metres). Dollarbirds have been known to share nesting trees with other species such as Galahs (*Eolophus roseicapillus*), Laughing Kookaburras (*Dacelo novaeguineae*), and Sacred Kingfishers (*Todiramphus sanctus*). They have also been known to take over nest sites from other birds, and have been observed to expel the nestlings of Laughing Kookaburras and a pair of incubating Cockatiels (*Nymphicus hollandicus*) (Higgins 1999).

Despite the Coraciidae being common in the wild, the family remains poorly studied. To date, most studies have concentrated on the *Coracias* rollers (see Fry & Fry 1999; Fry 2001). The majority of studies concerning Dollarbirds relate to wild populations (see Higgins 1999). There has been minimal research conducted on Dollarbird behaviour and biology when maintained

long-term in captivity. Most available information regarding captive Dollarbirds is anecdotal.

3.1 MORPHOMETRICS

Bare Parts:

- **Adult Male:** bill – red to orange-red (possible slight seasonal changes); legs and feet – orange-red to red-brown; soles of feet – pink; claws – black; gape – red to pale yellow; inside of mouth – pale yellow; iris – dark brown; orbital ring – brown-black.
- **Adult Female:** same as adult male.
- **Immature:** upper mandible – black-brown; lower mandible – mostly dull orange-yellow; gape – dull orange-yellow; orbital ring – buff.
- **Juvenile:** bill – glossy black; gape – light yellow; iris – dark brown; orbital ring – dark grey with salmon tinge at front.

Plumage:

- **Adult Male:** dark greenish blue body; darker and more blackish on the head; throat blue; most of the flight feathers and tail dark blue; pale blue wing spots on the wings, conspicuous when in flight.
- **Adult Female:** as adult male, but subtly duller in colouration.
- **Immature:** identical to adult, except retains juvenile remiges, retrices and greater upperwing-coverts; some lack the blue throat; the blue wing spot is paler and less well defined than the adult; will attain adult colouration at about 12 months.
- **Juvenile:** body brown-grey.
- **Nestling:** hatch naked.

Measurements:

- For a full range of measurements, refer to Table 2.
- Total length: 270 – 310 mm.
- Juveniles are significantly smaller than adults in wing, bill and tail measurements.

Weight:

- For a full range of weights, refer to Table 3.
- Juvenile males are lighter than adult males.
- Adult males generally lighter than adult females.

Table 2. Measurements of Dollarbird subspecies *E. orientalis pacificus* (mean (range); in mm) (Higgins 1999). Note that due to the small sample size for immature males, individual measurements are given.

	ADULT		IMMATURE		JUVENILE	
	Male	Female	Male	Female	Male	Female
Wing	192.5 (184-199)	193.5 (187-200)	185, 191	190.3 (185-192)	179.0 (143-195)	177.0 (147-198)
Tail	94.3 (88-99)	95.8 (88-100)	90, 91, 96	96.4 (91-102)	90.1 (65-101)	87.7 (73-102)
Bills	32.4 (30.3-35.0)	32.8 (73-102)	32.6, 34.6, 35.0	33.1 (31.3-35.4)	29.0 (24.0-32.3)	29.6 (26.1-32.5)
Tarsus	19.6 (18.3-21.1)	19.8 (18.4-20.7)	18.3, 19.1, 20.5	19.6 (18.3-21.5)	19.1 (17.8-20.9)	19.8 (19.0-20.6)
Toe C	28.5 (26.5-31.4)	28.1 (25.9-30.1)	30.5	28.9 (26.8-30.5)	28.0 (26.8-28.9)	26.8 (25.7-28.7)

Table 3. Weight measurements of Dollarbird subspecies *E. orientalis pacificus* (mean (range); in gm) (Higgins 1999).

	ADULT		JUVENILE	
	Male	Female	Male	Female
Weight	126.4 (95.3-180.3)	135.5 (105-172)	94.6 (51-115.5)	107.3 (75.4-143)

Sexing Methods:

- Visually – adult Dollarbirds are sexually dimorphic; adult females are more subtly coloured than the adult males (male and female juveniles and immature birds are visually identical).
- Surgical sexing through laparoscopy – the most reliable method of sexing, although it does pose a very small risk to the bird (through either anaesthetic deaths or bleeding from the procedure).
Advantages: the result is available instantly and an internal examination of the organs and air sacs can be undertaken on the bird simultaneously (S Gelis pers. comm.).
- DNA sexing –using feather or blood sample (blood sampling is more accurate as there is less chance of contamination).
Advantages: non-invasive and less stressful to the bird.

Additional taxonomic and anatomical characteristics are given in Appendix 1 (Fry & Fry 1999; Fry 2001; Henderson 1999; Higgins 1999; Simpson & Day 1989).

3.2 DISTRIBUTION

Dollarbirds are found throughout the New Guinea area including the Sunda and Solomon Islands and the Bismark Archipelago.

Their range extends west to the Andaman Islands and India, and north to Nepal, China, Japan and southern Russia (Fig. 1).

In Australia, Dollarbirds are restricted to northern and eastern Australia, occasionally extending as far as South Australia and Tasmania (Fig. 2).

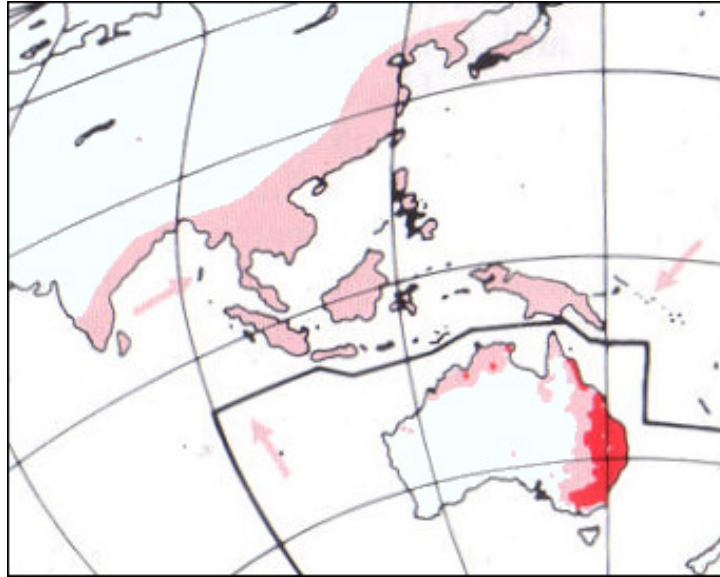


Figure 1. Map of the global distribution of the Dollarbird, *Eurystomus orientalis* (Higgins 1999).

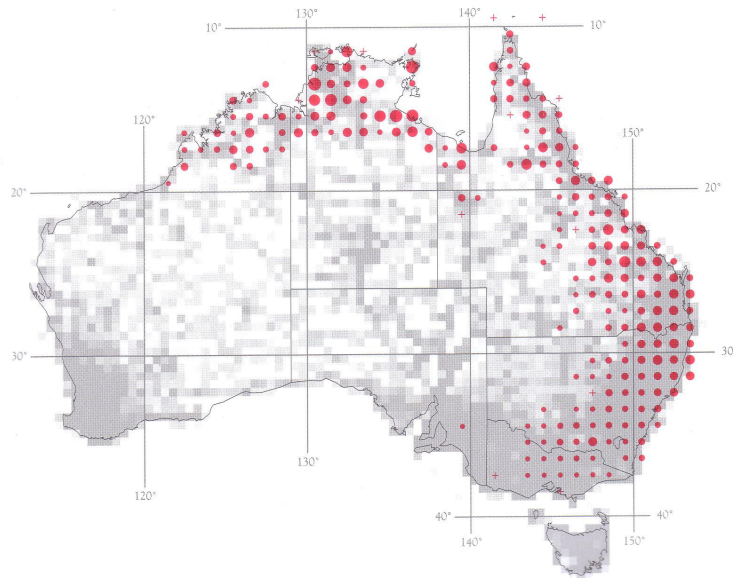


Figure 2. Map of the distribution of the Dollarbird subspecies *E. orientalis pacificus* populations in Australia (Barrett et al. 2003).

It is estimated that Dollarbird population densities in Australia vary between 5-14 individuals per km². Territories along creeks and streams are approximately 750 metres apart (Fry 2001).

3.3 CONSERVATION STATUS

IUCN Red List Conservation Status: Least Concern (BirdLife International 2004).

At an estimated 10,000,000 km², this species has a large global range (BirdLife International 2004). While precise figures for the extent of the wild population are not available, it is believed that Dollarbird populations are generally healthy. However, the different subspecies are not well distinguished, and sightings fail to differentiate between the native and non-breeding visiting populations (Fry 2001). Further research in this area is needed to ascertain the size and stability of subspecies populations.

3.4 DIET IN THE WILD

In the wild, Dollarbirds are insectivorous, feeding on large flying insects such as beetles, bugs, moths, mantids, grasshoppers, crickets and cicadas (Fry & Fry 1999; Henderson 1999; Trounson & Trounson 1987). Dollarbirds hawk their prey, catching insects on the wing. The insect is then either crushed and eaten mid-flight, or taken back to the perch where it may be battered before swallowing. Occasionally Dollarbirds in the wild have been known to take lizards and insects from the ground (Fry 2001).

Being a crepuscular species, Dollarbirds feed mainly during early morning, as well as late afternoon and evening. They will also hawk during and after rain, and in disturbed weather when insects may be active (Fry & Fry 1999).

3.5 LONGEVITY

3.5.1 In the Wild

There is no data available on the longevity of Dollarbirds in the wild. However, Blue Bellied Rollers (*Coracias cyanogaster*), which are in the same family as Dollarbirds, are likely to live over 20 years (Fry 2001).

3.5.2 In Captivity

As Dollarbirds in captivity are a comparatively recent occurrence, little information is available about their longevity. However, one

captive Dollarbird held at Taronga Zoo, NSW, lived for 15 years (E Schmelitschek pers. comm.).

3.5.3 Techniques Used to Determine Age

Juvenile, immature and adult Dollarbirds can be identified based on their plumage and colour of the bare parts (see section 3.1).

Using data collected from wild Dollarbirds, relative ages can be deduced by examination of feather and weight differences:

- *Feathers of the throat and foreneck* – in juveniles the tips are rounded, compared to lanceolate in immature and adult specimens.
- *Flight feathers* – in direct comparison, the p10 flight feather of juveniles and immatures has a narrower tip and is more pointed than that of the adults.
- *Retrices* – in direct comparison, the retrices of juveniles and immatures have narrower tips and are more pointed than that of the adults.
- *Weight* – juvenile males are lighter than adult males (Higgins 1999).

4. Housing Requirements

4.1 EXHIBIT SIZE

Dollarbirds are strong flyers and as such require large open areas in their enclosure to accommodate their flight. In the wild, they cannot fly in dense forests, but prefer the edges of clearings and open areas (Frith 1976). For this reason, indoor enclosures are not usually suitable as they cannot fulfill the Dollarbirds space requirements. Dollarbirds in captivity also have a tendency to become overweight, so a larger outdoor enclosure facilitates exercise.

Examples of enclosure sizes

Taronga Zoo, NSW

- Two male Dollarbirds are kept in a large mixed species walk-through enclosure approximately 35 x 12 x 10m high. There are two feeding stations located at either side of the enclosure that also act as catching areas (pers. obs.).

Territory Wildlife Park, NT

- A single Dollarbird is kept in a mixed species enclosure approximately 12 x 8 x 4m high (G Mayo pers. comm.).

Adelaide Zoo, SA

- Dollarbirds are kept in a mixed species enclosure approximately 4 x 6 x 6m high. There is a service/catch area at the rear of the enclosure of approximately 3 x 3 x 2.1m high (T Neilson pers. comm.).

4.2 HOLDING AREA DESIGN

Ideally, an off-display enclosure for Dollarbirds should be as large as possible, with sufficient room to allow for flight. Perches should be provided in varying diameters and placed at either end of the aviary to encourage flight. A solid roof and partially enclosed sides are preferable for smaller enclosures to provide security and prevent injury on the wire (C Alexander pers. comm.; Henderson 1999).

4.3 SPATIAL REQUIREMENTS

As stated previously, Dollarbirds require a large enclosure with ample room to allow them to fly and to facilitate exercise. See section 4.1.

4.4 POSITION OF ENCLOSURES

The position of the enclosure will depend on the type of enclosure and the available space. Considerations with regard to the position of the enclosure include:

- location of the enclosure in relation to support buildings
- flow of traffic through the enclosure
- source of water and electrical power
- effect of noise on the enclosure inhabitants and on those surrounding the enclosure
- the degree of protection from inclement weather
- protection from predators and pests (Clubb & Flammer 1994).

4.5 WEATHER PROTECTION

A section of the enclosure must provide shelter from extremes in weather, including wind, rain and sun. Food should be protected from rain, and undercover perches should be accessible.

4.6 TEMPERATURE REQUIREMENTS

As Dollarbirds are a temperate to tropical species, additional heating will be required if housed in colder climates. This can easily be provided by heat lamps.

Taronga Zoo provides heat lamps during cooler weather. However, their Dollarbirds have never been observed using them, despite temperatures reaching below 0°C during winter (E Schmelitschek pers. comm.).

4.7 SUBSTRATE

The substrate utilised will usually depend on the size of the enclosure, the other species housed, and the types of plantings within the enclosure. If no plantings are present, a concrete floor is ideal and is easy to clean and disinfect as needed. While using soil as the substrate is more natural, it does pose more of a health risk, as many avian pathogens can exist for extended periods of time in the soil (Clubb & Flammer 1994).

Adelaide Zoo and Territory Wildlife Park both use a natural soil substrate in the exhibit area, with Adelaide Zoo also using shell grit in the off display feed area (T Neilson pers. comm.). Taronga Zoo uses a natural substrate in the exhibit, with a concrete floor in the feed areas (pers. obs.).

4.8 NESTBOXES AND/OR NESTING MATERIAL

In the wild Dollarbirds will nest in tree cavities on the edges of forest or open woodlands (Trounson & Trounson 1987). They have also been known to nest in arboreal termite mounds (Higgins 1999). Eggs are laid on the wood dust at the bottom of the hollow. No special nesting material is utilised (Frith 1976).

In captivity, Dollarbirds will use nest boxes 230 x 230 x 450 mm high with an opening 100 mm in diameter (Fig. 3). They appear to have a preference for boxes located as high as possible; six to seven metres above the ground is advisable. An absence of vegetation either in front of the box or beneath the box also seems to be preferred, to facilitate flying into and out of the box (F Box pers. comm.).

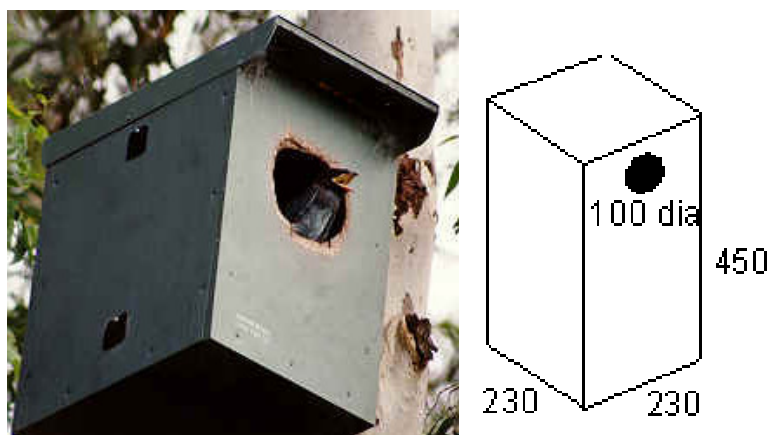


Figure 3. Nest box design used for Dollarbirds (Box n.d.).

4.9 ENCLOSURE FURNISHINGS

Perches and plantings

Perches in the enclosure can be provided by growing vegetation and by the placement of several 'dead' natural branches around the enclosure. There are a number of native and exotic plants that can be used in the enclosure, including *Eucalyptus* sp., *Loumandra* sp. and *Robinia* sp. (T Neilson pers. comm.).

Dollarbirds will seldom hop along a perch, and will rarely, if ever, swing about to face the other way. Instead, they prefer to fly from perch to perch as needed. Avoid placing thin, swaying branches in the enclosure, as Dollarbirds seem to prefer using robust branches a few centimeters thick (Fry 2001).

Feed stations

A central feeding station will allow for easy feeding and observation of all species within the enclosure. However, Dollarbirds can become aggressive around food in enclosures where they are the dominant species, therefore several feed stations may be required (C Alexander pers. comm.).

Water

Access to drinking water is essential. Dollarbirds at San Diego Zoo have not been observed drinking water out of a bowl (C Hall pers. comm.). Nevertheless, standing drinking water should be provided. The use of overhead sprinklers/misters in the enclosure provides not only an additional source of drinking water for Dollarbirds, but also allows the birds to bathe, thus encouraging preening and waterproofing of the feathers.

Adelaide Zoo provides a small pond approximately 1 x 1 metre with a 12 hour slow trickle to keep the water fresh (T Neilson pers. comm.). Taronga Zoo houses Dollarbirds with water birds, turtles and platypus, so a large pond is situated within the enclosure (pers. obs.).

5. General Husbandry

5.1 HYGIENE AND CLEANING

Good hygiene is essential to the wellbeing of any collection of birds. However, the level of hygiene maintained must be balanced with the level of disturbance this maintenance creates. If the inhabitants of an enclosure remain healthy, then regularly disinfecting the enclosure is unnecessary provided that organic debris is removed and not allowed to accumulate (Clubb & Flammer 1994).

Food and water containers should be made of stainless steel, hard plastic or crockery, and these should be cleaned thoroughly daily. Vetafarm Aviclens can be added to the drinking water on a daily basis to prevent bacterial and fungal growth in water containers. The addition of vitamin and mineral supplements to the water is not recommended as it can oxidize rapidly and provide an ideal growth media for bacteria and fungus (Clubb & Flammer 1994).

Feed preparation areas should be cleaned daily and disinfected with a suitable agent such as Vetafarm Avi-Care.

If natural substrate is used, this should be raked over regularly, and completely changed every six months. To prevent soil pathogens from becoming a health concern, regular tillage of the topsoil and the application of lime, formalin or another disinfectant will suffice (Swengel & Carpenter 1996).

5.2 RECORD KEEPING

Effective and detailed record keeping is an essential part of maintaining any animal in captivity. This is especially important for a species such as the Dollarbird which is not widely kept in captivity. Quality records will not only allow the analysis of trends but also collaboration between other institutions keeping Dollarbirds. In this way, an improved understanding of the species can be obtained. Detailed records are also invaluable when the birds are transferred to another institution.

Record keeping should incorporate:

- Individual file: details such as age and sex, rearing records, genealogical summary, identification and origin of the bird (i.e. if captive bred or wild caught).

- Medical file: records of any illness, veterinary care and treatments that the bird has received, including annual physical examination results.
- Breeding file: all records of breeding attempts, successful breeding and reproductive behaviour.
- Daily log: day-to-day care including behaviours observed, diet and transfers between enclosures.

(Ellis et al. 1996; National Research Council 2004).

5.3 METHODS OF IDENTIFICATION

Permanent identification by microchip is advised. The preferred location of microchip placement for the Order Coraciiformes is subcutaneously, dorsal midline at the base of the neck. However, for birds as small as Dollarbirds it is preferable to place the microchip in the superficial pectoral muscle on the left side (Coraciiformes TAG 2005; S Gelis pers. comm.).

Leg bands are also used for identification in Dollarbirds, and are particularly suitable for quick visual identification. The specifications for Dollarbird bands are:

Size: 08

Metal: Aluminium

Internal diameter: 6.5mm

Height: 9.0mm

Gauge: 1.0mm

(ABBBS 2000).

5.4 ROUTINE DATA COLLECTION

Aside from daily record keeping requirements (husbandry and veterinary), no other data is at present routinely collected for Dollarbirds.

6. Feeding Requirements

Little is known about the nutritional requirements of Dollarbirds in captivity. In the wild, Dollarbirds consume a wide variety of insects. In captivity, it is not possible to duplicate this variety. It is therefore vital to ensure a balanced diet that corrects the attendant nutrient deficiencies (Bernard & Allen 1997). Regular evaluation and review of the diet to ensure that it is meeting the nutritional requirements of the bird is required. The physical condition and behaviour of the bird provide key indicators as to how suitable the diet may be, and indicate if any alterations are required (National Research Council 2004).

Insectivorous birds will regurgitate pellets (called casting) containing the indigestible portions of their diet (such as the chitinous exoskeleton, wings, legs and heads of insects). Coraciidae species can cast up to 12 pellets during the day, with one to two at night. The pellets are 10-15 mm wide and up to 30 mm long (Fry 2001).

6.1 CAPTIVE DIET

Although there are variations to the basic Dollarbird diet in captivity, it should contain a relatively high protein content. As Dollarbirds are insectivorous, live insects should form a component of their diet. They will however adapt to an artificial diet quite readily, after a period of adjustment.

When a new bird enters the collection, it may need to be 'taught' what to eat, particularly if it is a rescue bird from the wild. This process is called 'meating-off'. In the case of Dollarbirds, this may involve dipping live insects in a nectar or honey solution, then rolling them in an insectivore powder (such as Wombaroo Insectivore or Vetafarm InsectaPro). The insect should not be coated so much that it cannot move, as movement is needed to stimulate the bird to eat. Over time, newly acquired birds will develop a 'taste' for the powdered artificial food, which can then form the bulk of their diet (Vince 1996). Alternatively, housing a new Dollarbird in an established aviary will allow it to follow the example of the other inhabitants (although this may not be possible if quarantine requirements need to be implemented). Placing mealworms in the food dish with the artificial diet may also stimulate new birds to investigate due to the movement of the mealworms (C Alexander pers. comm.).

Examples of Dollarbird Diets

Taronga Zoo, NSW:

- Approximately 2.25 lt of dog kibble (Pal Pedigree Puppy is currently used) mixed with 0.85 lt water. The mixture is allowed to sit for several hours before adding 1.0 lt of Wombaroo Insectivore. This is then left to soak overnight before adding kangaroo mince (all measurements are by volume) (E Schmelitschek pers. comm.).

Territory Wildlife Park, NT:

- Prepared meat mix containing mince, bran, crushed dog food, grated egg, calcium supplement and a multivitamin supplement, with the addition of mealworms and crickets (G Mayo pers. comm.).

Adelaide Zoo, SA:

- 4 kg mince, 4 heaped cups Wombaroo Insectivore, 300 gm Wombaroo Parrot Crumbles, 4.5 cups pollard, 4.5 cups wheat germ, 0.25 cup calcium. Drain excess blood from mince, and then add Wombaroo Insectivore and calcium powder. Gradually add the remaining ingredients starting with the parrot crumbles until the mix attains a 'crumbly' consistency (T Neilson pers. comm.).

San Diego Zoo, CA:

- 1 tbs dog kibble (Iams Weight Control for Dogs), 1 tbs Natural Balance Zoo Carnivore Diet 5, 10 mealworms, 10 adult crickets and 2 whole pinkie mice (this amount is per bird) (C Hall pers. comm.).

Norma Henderson (WIRES NSW):

- Pinkie mice, insects and mealworms given daily, or substituted with a mixture containing Wombaroo Insectivore, mince, calcium supplement, dog kibble and hard boiled egg yolk (Henderson 1999).

It has been observed that Dollarbirds in the wild may ingest artificial objects such as fragments of shell, plastic and stones, possibly as an aid to grinding up the hard exoskeleton of their prey (Nakamura & Tabata 1988). Whilst Dollarbirds in captivity do not consume as much live food as wild Dollarbirds, they should nevertheless have access to small stones, or similar, for this purpose.

6.2 SUPPLEMENTS

Nutrient deficiencies, in particular calcium, are often a problem when feeding insectivorous birds. While dusting insects with calcium powder prior to feeding is one method of providing extra calcium, this method is not very consistent. The most effective

method of providing calcium supplementation is by gut loading insects with a high calcium diet (Bernard & Allen 1997). This has proved beneficial in both crickets and mealworms (Allen & Oftedal 1989; Zwart & Rulkens 1979). At San Diego Zoo, all insects are gut loaded on Marion Zoological Insect Supplement for 72 hours prior to feeding (C Hall pers. comm.).

If a general vitamin and mineral supplement is required, there are various products available. Nekton Tonic I is specifically formulated for insectivores, however this is not commercially available in Australia. Vetafarm Soluvet, and Vetafarm Calcivet or Vetafarm D'Nutrical are suitable alternatives.

If a bird is eating a balanced diet, then the addition of extra supplements is unnecessary and can lead to an overabundance of certain vitamins and minerals. Apart from the gut loading of insects, San Diego Zoo found the diet they provide for their Dollarbirds required no additional supplementation (C Hall pers. comm.).

6.3 PRESENTATION OF FOOD

As Dollarbirds are aerial feeders in the wild, they may initially be reluctant to come to the ground to feed in captivity. However, captive Dollarbirds will learn quickly where food is located, even if placed on the ground (E Schmelitschek pers. comm.). As an alternative, the food dish can be placed in an elevated position, at least 90 cm above the ground. If in an open area, then the birds are able to view the food and swoop down to feed (Vince 1996). Placing the food in an elevated position also reduces accessibility by vermin (Swengel & Carpenter 1996).

At Taronga Zoo, food is placed in feed stations early each morning. This allows keepers to visually assess and count all birds that come to the stations for food. Later in the morning, a second round of food is placed throughout the enclosure to accommodate the various species of birds present. Live food (crickets and mealworms) is presented during early afternoon as feeding enrichment (E Schmelitschek pers. comm.).

7. Handling and Transport

7.1 TIMING OF CAPTURE AND HANDLING

There is no specific time best suited for capturing birds. At Taronga Zoo, due to the size of the enclosure, Dollarbirds are trapped in the feed stations when food is presented early in the morning, then netted out into a transport container as needed (E Schmelitschek pers. comm.).

7.2 CATCHING BAGS

Not applicable.

7.3 CAPTURE AND RESTRAINT TECHNIQUES

Capture techniques will depend on the type of enclosure, but will involve either netting or towelling the bird. If the enclosure is large, the bird may need to be enticed into a smaller service/catch area.

Once captured, standard bird restraint methods can be used, ensuring that the claws and beak are not able to injure the keeper.

7.4 WEIGHING AND EXAMINATION

It is best to weigh birds inside a closed cardboard box (or similar) placed on the scales. As well as reducing stress, this calms the bird so that it remains inactive long enough for a reading to be taken.

7.5 RELEASE

Birds should be released into a new enclosure as early in the day as possible to allow sufficient time before dark for the birds to become familiar with their new environment. This is particularly important if the enclosure is already inhabited.

When new birds are introduced into a mixed species enclosure, there is always a degree of stress imposed on the inhabitants, both new and old, until a new hierarchy is determined. This stress may lead to subclinical disease problems, so careful observation is required until the inhabitants settle (Perry 1994).

7.6 TRANSPORT REQUIREMENTS

Specifications for the international transport of live animals are set by the International Air Transport Association (IATA) (2007), with many domestic carriers adopting these standards. Prior to any transportation, birds should be checked by veterinary staff to verify that they are healthy.

7.6.1 Box Design

The type of container used to transport Dollarbirds will depend in part on the distance travelled. The following guidelines provided by the IATA should be adhered to:

- The transport container should be secure and darkened as birds will settle faster in a darkened container.
- The transport container should provide enough room for the bird to stand, turn around, and flex its wings, without damage to its tail.
- The transport container should be able to be securely closed to prevent injury or escape.
- If the transport container is to be reused, it should be constructed of material that is able to be cleaned thoroughly and disinfected.
- Transport containers should be of sturdy enough construction to survive dropping and minor impacts during transport.
- All sides except the front should be enclosed. The front provides ventilation and should never be obstructed by other cargo. Ventilation holes should also be present in at least three of the four sides.
- The flooring should provide a secure footing for the bird. Dollarbirds should also be provided with a perch.
- The floor of the transport container should be sealed so as to prevent the escape of faecal matter.

(Department of Environment and Heritage 2006; IATA 2007).

Types of transport containers include wire front cat carriers (such as the Hagen Pet Cargo Carrier), which are suitable for short distances by land. Wooden transport boxes specifically designed for birds, which are usually made in-house or sourced locally, are ideal for air travel.

Labeling is extremely important – always display ‘Live Animal’ and ‘This way up’ labels on all sides of transport containers when shipping (minimum dimensions of labels 10 x 15 cm). Addressee and sender details, as well as any permits necessary should be attached to the outside of the box (Department of Environment and Heritage 2006).

7.6.2 Furnishings

With the exception of a perch, no special furnishings are required in transport containers for Dollarbirds.

7.6.3 Water and Food

Water should be provided in a deep container, with a small amount of cotton wool or sponge inside to prevent spillage. This should be checked regularly and replaced at least every eight hours. Food should be provided and replaced at least every 24 hours. Due to the possibility of Dollarbirds not drinking water from a container, providing food with a high moisture content, such as soaked dog food, will prevent dehydration during transit (C Hall pers. comm.).

7.6.4 Animals per Box

Dollarbirds can become territorial when placed in groups (E Schmelitschek pers. comm.). Wherever possible, Dollarbirds should be transported singly, so as to prevent injury during transport.

7.6.5 Timing of Transportation

Transportation should not occur where the bird/s will be exposed to temperatures over 32°C (89.6°F).

Ideally, transportation of breeding birds should only occur during the non-breeding season, allowing sufficient time for the birds to settle into their new enclosure prior to the onset of the breeding season (Swengel & Carpenter 1996).

7.6.6 Release from Box

Birds should be released into their new enclosure as early in the day as possible, to allow sufficient time before dark for the birds to become familiar with their new environment. This is particularly important if the enclosure is already inhabited.

It is not unusual for new birds to refuse food for a few days after relocation. Therefore, new birds should be weighed on arrival, and carefully monitored for weight loss until they settle into their new surroundings. Forced feeding should only occur if weight loss is greater than 15% of the original weight (Clubb & Flammer 1994).

8. Health Requirements

8.1 DAILY HEALTH CHECKS

A bird's health can be monitored daily by means of a visual examination. Symptoms to be aware of include:

- ruffling of feathers
- partially closed eyes
- laboured or open mouthed breathing
- sitting on the bottom of the enclosure
- abnormalities in body function (such as wing droop, shifting weight from one leg to another or standing on the metatarsus rather than the foot)
- discharge from the nostrils, eyes or mouth
- signs of vomiting or regurgitation
- injury or bleeding
- refusal of food

(Harrison & Ritchie 1994)

If any of these symptoms are observed, the bird should be removed from the enclosure and a thorough examination undertaken.

8.2 DETAILED PHYSICAL EXAMINATION

Ideally, birds should undergo an annual physical examination, preferably during the non-breeding season (Harrison & Ritchie 1994). However, examination by veterinary staff should be performed whenever any of the symptoms described in section 8.1 are observed.

8.2.1 Chemical Restraint

Anaesthetic: Isoflurane induction by facemask, then maintenance by endotracheal tube for extended procedures (S Gelis pers. comm.).

8.2.2 Physical Examination

The following list is presented as a guide to areas of interest that should be included during a physical examination of Dollarbirds.

History: A history of the bird should be available, including age, sex, previous medical concerns, diet, housing environment and any noticeable changes in the bird (such as increase or decrease in food consumption and changes in the birds behaviour).

Head and Eyes: Check for swollen eyelids, and discharge or change of colour around the eyes. Use a small torch to check papillary response (each eye responds independently). Check the nares for signs of discharge or blockage.

Beak: Examine for bite and overgrowth as well as uneven wear. In Dollarbirds, particular attention should be paid to the tip of the beak, which can become worn down during feeding (C Alexander pers. comm.).

Oral Cavity: Gently open the mouth and examine the tongue and interior of the mouth.

Auditory Canal: Examine for exudates, infection or blood.

Neck and Thorax: By carefully palpating the neck, trachea and oesophagus, possible blockages or deformities of the vertebrae can be detected. The thoracic cavity can also be palpated to determine if the thyroid glands are enlarged (goiter).

Body Condition Index and Weight: Palpation of the pectoral muscles and keel can determine the overall body condition of the bird, usually indicated by the Body Condition Index (BCI) rating of 1 (poor) to 5 (excellent). This can be compared to previous BCI readings. A drop in BCI can indicate infection or nutritional problems.

Abdomen: Gentle palpation of the abdomen will reveal any internal masses, fluid or ovulated eggs. Check the vent area for any faeces or urates that have accumulated on the feathers. Check the uropygial gland for enlargement.

Skin and Plumage: Check for overall level of hydration of the skin, evidence of mites, lice or other external parasites, skin swellings, or damaged and missing feathers. Feathers should be checked for signs of stress bars which can indicate nutritional deficiencies, hormonal imbalance or stress. Check for feathers missing on the legs and thighs, which may indicate feather mutilation.

Wings: Extend each wing out fully and palpate each joint and bone. Assess muscle tone. Check for signs of swelling or abrasions.

Legs: Palpate each leg bone and joint, and assess the muscle tone. Check toes and the bottom of the foot for signs of bumblefoot.

Auscultation: Using a stethoscope, listen for the heart rate. Respiratory problems can be detected by listening to the thoracic region. Aspergillosis can often be detected in advanced cases by listening to the lungs and air sacs.

Temperature: Although not commonly part of a physical examination, a bird's temperature is generally around 40°C (104°F). Elevated temperature may indicate infection or stress.

Faecal Smear: This procedure should be carried out regularly to detect parasite infection before clinical symptoms appear, and to reduce the likelihood of the parasite spreading through the collection.

Blood Collection: Preferred site is the right jugular vein – wetting the feathers with alcohol will make the vein more visible. Apply pressure on the vein for one minute after to prevent haematoma.

(Harrison & Ritchie 1994; National Research Council 2004; Olsen et al. 1996; S Gelis pers. comm.).

8.3 ROUTINE TREATMENTS

No vaccinations are required (S Gelis pers. comm.), however aviary birds should routinely be tested for parasites such as worms, and treated accordingly.

8.4 KNOWN HEALTH PROBLEMS

As with most birds, Dollarbirds are prone to bacterial diseases (such as *E. coli* and Chlamydiosis), fungal diseases (such as Aspergillosis and Candidiasis) and parasitic diseases (such as Coccidiosis, intestinal worms, feather mites and lice). Many of these diseases are husbandry related, and should not become major problems provided that the enclosure is kept hygienic and nutrition and husbandry requirements are met.

Anecdotally, there are two health related conditions that captive Dollarbirds are particularly prone to: obesity and beak abnormalities (C Alexander pers. comm.).

Obesity: Dollarbirds in captivity respond very quickly to routine, and as such will tend to sit and wait for food to be provided. This can lead to obesity, which in turn can lead to numerous other health-related problems. Providing an enclosure large enough to allow for flight, and feeding enrichment (i.e. encouraging the birds to hawk for their food by throwing insects or meat pieces into the air), will help to overcome this problem.

Beak abnormalities: Dollarbirds have adapted to hawking for their food. In captivity, much of their food is presented either in a feed dish, or in the case of Taronga Zoo, as live food on a large rock. The stabbing motion that Dollarbirds use to pick food up off a flat surface can erode the tip of their beak.

8.5 QUARANTINE REQUIREMENTS

All new birds should be quarantined for a minimum of six weeks, however the longer the quarantine period the less likely that a disease or pathogen will be introduced into the collection. During quarantine, regular faecal smears (with a minimum of two clear faecal floats), gram stains and blood tests should be carried out to ensure that the bird is as disease-free as possible (S Gelis pers. comm.).

Cross contamination between enclosures can be reduced by the use of an antibiotic or antibacterial footbath, in which the keepers can dip the soles of their shoes. This should be changed weekly (Swengel & Carpenter 1996).

9. Behaviour

9.1 ACTIVITY

In general, Dollarbirds are an inactive bird, spending much of their time perched high up in the enclosure. Although feeding mainly at dawn and dusk, Dollarbirds may feed sporadically throughout the day, often darting out from their perch to catch an insect (Higgins 1999).

9.2 SOCIAL BEHAVIOUR

Dollarbirds in the wild are usually found singly or in pairs, although they may form family groups after breeding (Fry 1999). In captivity, Dollarbirds prefer to perch alone with little or no interaction with other birds in the enclosure (E Schmelitschek pers. comm.). Dollarbirds are assertive birds and able to 'stand-up' for themselves when placed in a conflict situation (T Neilson pers. comm.).

In the wild, Dollarbirds will engage in territorial and courtship display flights which can last several minutes. This involves almost constant calling as the bird rises high about the territory, then nose dives at speed, before rapidly rolling from side to side as it levels out (Fry & Fry 1999). The rolling is usually a rapid twisting through 180-270°, and is never 360° (Fry 2001).

Due to the limited space available in a captive environment, such territorial displays are rarely seen. However, at Taronga Zoo, where two males are kept together, there are occasional 'stand-offs' between the two males, with displays of open-beak threatening behaviour. These displays have never resulted in injury (E Schmelitschek pers. comm.).

9.3 REPRODUCTIVE BEHAVIOUR

Courtship between Dollarbirds often involves loud calling and display flights. Pairs have also been seen parading towards each other, with neck arched and feathers fluffed, bobbing and curtsying, while giving low calls. A male has also been observed rubbing his bill about the females head whilst calling (Higgins 1999). Courtship feeding of the female by the male has also been observed. Mutual preening has been observed in rollers, but not specifically in Dollarbirds (Fry 2001).

Pairs will vocalize in unison in a loud chattering fashion whilst bobbing their heads and tail. This behaviour is usually displayed in the morning, and appears to be a prelude to mating. Pairs will rarely roost side by side (C Hall pers. comm.).

Dollarbirds will nest in mixed species collections in captivity, although some territorial aggression may be displayed to other birds. At San Diego Zoo, breeding Dollarbirds have been observed pursuing smaller birds throughout the enclosure, although this has never resulted in physical aggression and has always been short-lived (C Hall pers. comm.).

9.4 BATHING

Bathing in birds should be encouraged as it promotes normal grooming activities, which in turn aids in waterproofing the feathers (Perry 1994). The Cinnamon Roller (*Eurystomus glaucurus*) has been observed diving completely into water from a perch, whilst Dollarbirds in the wild have been observed rain-bathing (Fry 2001).

9.5 BEHAVIOURAL PROBLEMS

Migratory birds kept in captivity may undergo what can be known as migratory restlessness, or 'Zugunruhe'. This is controlled by photoperiod, and is characterized by a fluttering of the wings while perching, often aligned towards the direction of migration. This has been shown in part to be an inherited trait and will usually last for as long as migration would normally take (Deinlein n.d.). Although this is a well documented phenomenon (Agatsuma & Ramenofsky 2006; Helm 2006; Helm & Gwinner 2006), Taronga Zoo has never noticed this problem with their captive Dollarbirds (although they have been in captivity for upwards of five years) (C Alexander pers. comm.).

Dollarbirds can become aggressive around food, which may be directed towards the keepers. Taronga Zoo found that one Dollarbird would swoop any keeper that entered the enclosure in an effort to find food. As this was a public walk-through enclosure, this bird had to be separated due to the possibility of it swooping a member of the public and causing injury (E Schmelitschek pers. comm.).

Other behavioural problems specific to Dollarbirds are unknown.

9.6 SIGNS OF STRESS

Behavioural indications of stress in Dollarbirds are unknown; however, for birds in general, stress signs include changes in

behaviour (either quieter or more flighty), decreased appetite and changes in appearance (feather quality or general deterioration of health). Any signs of stress should be treated, and the cause identified, as stress often leads to subclinical disease problems (Perry 1994).

9.7 BEHAVIOURAL ENRICHMENT

The primary goal of behavioural enrichment is to promote species-typical behaviour and reduce or eradicate the stereotypical behaviours often associated with captivity such as pacing, feather picking and self-mutilation (Forthman & Ogden 2008; Sivakumaran & Thiyagesan 2003). Even in the most naturalistic enclosure complete with trees and space to fly, birds can still act in a monotonous manner. Behavioural enrichment concepts need to be incorporated into the enclosure design and daily husbandry routine (Wee 2004). Knowledge of the behaviour and physiology of Dollarbirds in the wild can provide clues for behavioural enrichment in captivity.

Presentation and variety of food

Feeding enrichment is the easiest form of behavioural enrichment. Providing different types of foods in different manners can increase the time spent foraging for food (Forthman & Ogden 2008). Whilst it is well known that parrots spend a great deal of time foraging for food in the wild (up to 90%) (Field & Thomoas 2000), Dollarbirds are generally inactive for much of the day, feeding mainly during dawn and dusk (Fry 2001). This can pose some challenges when keeping them in captivity.

At Taronga Zoo, live food is provided during the early afternoon instead of with the morning meat mix feed (E Schmelitschek pers. comm.). Another feed enrichment method is to suspend PVC pipes containing live insects near the roof of the enclosure. Holes drilled into the pipes allow the insects to escape, where the Dollarbirds can then fly out and catch them.

Social enrichment

Providing for social interaction and companionship within appropriate social groupings can also provide stimulation and prevent problem behaviours (Field & Thomoas 2000). Note however, that aggression can occur between Dollarbirds when housed together (G Mayo pers. comm.), as can displacement of more timid species in a mixed species collection (C Hall pers. comm.).

Enclosure design enrichment

Natural branches should be provided for perching in a variety of sizes and shapes. In view of the preference of Dollarbirds to be in elevated positions, perches should be as high as practically

possible. This provides the birds with good aerial views, thereby providing mental stimulation. Some perches should also be provided undercover for shelter and security (Field & Thomoas 2000). If perches are provided at a reasonable distance apart, this allows for flight from perch to perch, which in turn provides exercise for the birds.

Another form of enrichment can be provided by regularly replacing browse cuttings, which provide new 'environments' for the birds to explore. Creating mounds of soil on the ground in various locations around the enclosure can also provide cover for birds when they are on the ground (Field & Thomoas 2000).

Water in the enclosure to allow bathing, or a sprinkler system that will allow birds to cool down during hot weather can also provide variation to the daily routine (Wee 2004).

9.8 INTRODUCTIONS AND REMOVALS

Introducing a new Dollarbird to an established enclosure needs to be undertaken carefully, particularly if Dollarbirds already inhabit the enclosure. When Taronga Zoo added a third Dollarbird to their collection, the first two were removed for a period of time to allow the new bird to settle into its new environment before encountering the original Dollarbirds (E Schmelitschek pers. comm.).

9.9 INTRASPECIFIC COMPATIBILITY

As Dollarbirds are not a flock bird, care needs to be taken when in a captive environment as aggression can lead to injury or even the death of a cage-mate (G Mayo pers. comm.). Aggression between males during the onset of the breeding season has also been observed at Taronga Zoo (E Schmelitschek pers. comm.).

9.10 INTERSPECIFIC COMPATIBILITY

Dollarbirds will cope quite well in a mixed species enclosure, provided that there is sufficient space and perches, and will generally inhabit the upper levels of an enclosure.

At Adelaide Zoo, Dollarbirds have been successfully kept with Red-tailed Black Cockatoo (*Calyptorhynchus banksii*), Blue-winged Kookaburra (*Dacelo leachii*), Pheasant Coucal (*Centropus phasianinus*), Pekin Robin (*Leiothrix lutea*), Pied Stilt (*Himantopus himantopus*), Bar-shouldered Dove (*Geopelia humeralis*), Sacred Kingfisher (*Todiramphus sanctus*) and Palm Cockatoo (*Probosciger aterrimus*) (T Neilson pers. comm.). At Territory Wildlife Park, Dollarbirds are mixed with Red-collared

Lorikeets (*Trichoglossus rubritorquis*), Partridge Pigeons (*Geophaps smithii*), Channel-billed Cuckoo (*Scythrops novaehollandiae*) and Pheasant Coucal (G Mayo pers. comm.). They have also been mixed successfully with other non-avian species, for example at Taronga Zoo they share an enclosure with rock wallaby, echidna and turtles (E Schmelitschek pers. comm.).

Care needs to be taken when housing Dollarbirds with timid species of birds which can easily become stressed around the more assertive Dollarbirds (C Hall pers. comm.).

9.11 SUITABILITY TO CAPTIVITY

Dollarbirds are a robust species that adapt well to captive situations. Although there is some correlation between degree of insectivory and the success of the species in captivity (Muller 1976), Dollarbirds seem to cope well after adjusting to an artificial diet. However, care needs to be taken that captive birds do not become overweight (C Alexander pers. comm.).

10. Breeding

10.1 MATING SYSTEM

Dollarbirds are essentially monogamous, with each breeding pair living in a defended territory (Fry & Fry 1999). In wild Dollarbirds, the first member of a pair will arrive at the breeding site where it will spend the time until its mate arrives perched near the nest. Once its mate arrives, courtship begins with display flights accompanied by loud calling until they both return to the nest site (Higgins 1999).

10.2 EASE OF BREEDING

The onset of the breeding season is largely controlled by environmental factors such as photoperiod, rainfall, abundance of food and availability of a suitable nest site. In captivity, these cues may need to be provided artificially so that they mimic the predisposing conditions in the wild.

It should be noted that there are a variety of environmental conditions that can reduce the likelihood of breeding. These include stress caused by disease, inclement weather, relocation to new enclosures, intraspecific conflict and interference from humans (Mirande et al. 1996).

10.3 REPRODUCTIVE CONDITION

10.3.1 Females

Unknown.

10.3.2 Males

Unknown.

10.4 TECHNIQUES USED TO CONTROL BREEDING

There are no specific contraceptive methods used for Dollarbirds, apart from the removal of eggs or separation of the sexes (Coraciiformes TAG 2007). The use of dummy/fake eggs can delay additional clutches in breeding Dollarbirds (C Hall pers. comm.).

10.5 OCCURRENCE OF HYBRIDS

Unknown.

10.6 TIMING OF BREEDING

The breeding season for Dollarbirds in Australia is during the spring and early summer, generally from October to December, sometimes extending into early January, with fledging occurring December to February (Higgins 1999).

10.7 AGE AT FIRST BREEDING AND LAST BREEDING

Dollarbirds become sexually mature at approximately two years of age (C Alexander pers. comm.). The reproductive lifespan of Dollarbirds is unknown.

10.8 ABILITY TO BREED EVERY YEAR

Given the right conditions, Dollarbirds will breed each year. In the wild they may even return to the same breeding site each year (Forshaw & Cooper 1993).

10.9 ABILITY TO BREED MORE THAN ONCE PER YEAR

Dollarbirds are able to double brood, with some observations in wild Dollarbirds that they use a different nest site for the second clutch (Higgins 1999). In captivity, Dollarbirds have double clutched following the removal of eggs for artificial incubation (C Hall pers. comm.).

10.10 NESTING, HOLLOW OR OTHER REQUIREMENTS

In the wild, Dollarbirds prefer to nest on average 14.6 metres off the ground. Eggs are laid in the wood dust at the bottom of the hollow – no nesting material is utilised (Beruldsen 2003; Higgins 1999)

In captivity, a nesting box measuring 230 x 230 x 450 mm high with an entrance hole diameter of 100 mm is acceptable, mounted as high above the ground as possible (Box n.d.). To facilitate monitoring of the eggs and the behaviour of adults, it is advisable to mount a video camera inside the nesting box.

10.11 BREEDING DIET

When breeding, the dietary requirements of the female change. Increases in protein and calcium may be necessary to provide for egg production and improved hatchability of the embryo. Calcium deficiency can cause decalcification of the female's skeleton, thin shelled eggs, egg binding and calcium-deficient abnormalities in the chicks (Jordan 1989). Other nutrients that are beneficial to egg production include vitamins A, B12, riboflavin and zinc. Vitamin E, riboflavin, folic acid, zinc, iron, copper and manganese may also improve hatchability (Brue 1994).

It has also been shown that supplying a breeding diet to the parents during chick growth provides multiple benefits. Not only does it decrease the duration of time the chick spends in the nest, but it promotes rapid recovery of the female, both physiologically and in body condition, for returning to nesting (Brue 1994).

At San Diego Zoo, breeding Dollarbirds are given an extra dish of the maintenance diet in the afternoon, along with additional crickets and mealworms. This is provided on a daily basis from four days prior to the eggs hatching, and continued until one month after fledging of the chicks. Crickets and mealworms are fed as needed when there are chicks in the nest (C Hall pers. comm.).

10.12 INCUBATION PERIOD

Both sexes will incubate the eggs (Henderson 1999), with incubation commencing with the first egg (Fry & Fry 1999).

Incubation period: 20-22 days (C Hall pers. comm.).

10.13 CLUTCH SIZE

Dollarbirds will lay three to five eggs (usually four) at one day intervals. Eggs are a glossy, translucent white; size is 37 x 29 mm (Beruldsen 2003; Fry & Fry 1999).

10.14 AGE AT WEANING/FLEDGING

Both parents will feed the nestlings and fledglings. As the nestlings age, they will come to the entrance of the box for food (Higgins 1999). Nestlings will cast pellets, which the parents leave in the nest along with the faeces (Nakamura & Tabata 1988). Fledglings adopt a begging posture with rapid lowering and raising of the lower mandible, although the bill is not opened more than 20° (Higgins 1999).

It has been observed that wild Dollarbirds may bring artificial 'tools' (such as fragments of shell, plastic and stones) to the nest, possibly as an aid to grinding up the hard chitinous exoskeleton of their prey. These tools are ingested by the parents as well as the chicks (Nakamura & Tabata 1988).

Fledging age: 28-30 days (Higgins 1999).

Weaning age: 52 days (C Hall pers. comm.).

10.15 AGE OF REMOVAL FROM PARENTS

Once the chicks have fledged and are feeding for themselves, they can be removed from the parents. This occurs approximately three weeks after fledging (C Hall pers. comm.). Careful observation is needed at this time to ensure that the fledglings continue to feed once removed. Daily weighing will indicate if any start to lose condition and which birds may need support feeding.

10.16 GROWTH AND DEVELOPMENT

The approximate age of Coraciidae species at each developmental stage is as follows:

- Eyes open at 7-12 days
- Mobile and active at 14 days
- Start casting pellets at 20 days
- Fledging (and flying) occurs at 25-30 days

(Fry 2001; Witman 2007).

Once fledged, the European Roller (*Coracias garrulous*) will start to forage within five days, becoming fully independent approximately three weeks later (Fry 2001). It could be assumed that Dollarbirds will progress in a similar fashion.

Growth rates of Eastern Dollarbirds (*E. orientalis orientalis*) are shown in Figure 4.

Moults

Shortly after fledging, juveniles will undergo the first partial pre-basic moult, where all feathers are moulted except the remiges, retrices and greater upperwing-coverts (a full pre-basic moult is a complete replacement of body and flight feathers). The second moult is a full pre-basic moult, and appears to occur at about the same time as post-breeding adults. It is during this second moult that immature Dollarbirds attain their adult plumage. Adult Dollarbirds will moult annually (pre-basic) after the breeding season (Higgins 1999).

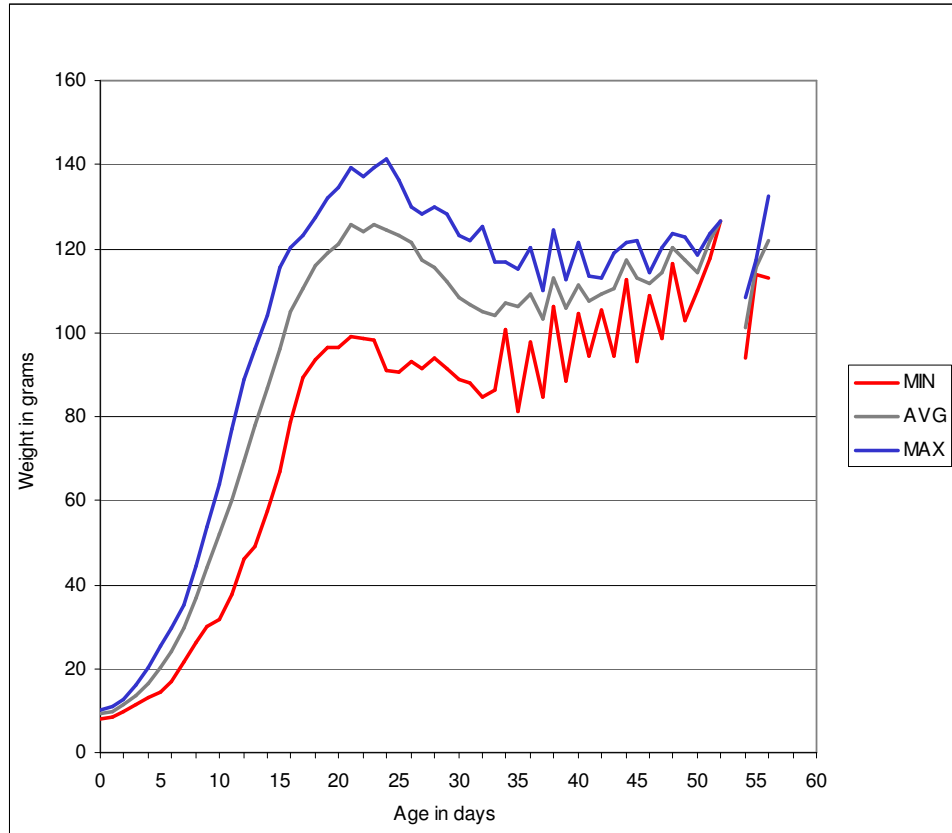


Figure 4. Average chick growth curves for the Eastern Dollarbird (*E. orientalis orientalis*) at San Diego Zoo (C Hall pers. comm.).

11. Artificial Incubation and Rearing of Birds

Artificial incubation of eggs and hand rearing of chicks is a widely practiced technique that aims to increase egg production through double brooding, and decrease embryo mortality. Although parent reared birds are preferred (Witman 2007), it is occasionally necessary to artificially incubate and/or hand rear chicks due to inexperienced parenting, injury or neglect.

11.1 INCUBATOR TYPE

There are two basic types of incubators – still-air incubators and fan-forced incubators. Both have advantages and disadvantages; although the fan-forced incubators are more common (see Jordan 1989; Kuehler & Good 1990 for further information).

Whichever type of incubator is used, a reliable thermostat to control the temperature is crucial. An accurate dry-bulb thermometer should also be placed in the incubator, in a position where the temperature can be read from outside. It may be advisable to place several thermometers in different areas of the incubator to measure the temperature (Jordan 1989). This is particularly important when using a still-air incubator, where temperature variations can occur throughout the incubator. A wet-bulb thermometer is also required to measure humidity levels.

If the incubator used does not turn the eggs automatically, this will need to be performed manually. The egg is marked with an 'X' on one side and an 'O' on the other – allowing a judgment on how much the egg needs rotating. The egg should be turned at regular intervals. The egg should be placed horizontally on the tray, and then turned around the longitudinal axis to prevent supercoiling of the chalazae (albuminous cord that attaches the yolk to the eggshell membrane) (Gabel & Mahan 1996).

11.2 INCUBATION TEMPERATURES AND HUMIDITY

As small temperature variations can affect embryo development, it is critical that the temperature and humidity remain constant throughout the incubation period. The temperature inside the incubator will remain more stable if the ambient temperature in the room is stable (Jordan 1989).

Humidity can be controlled by the addition of water to a reservoir, misting, or regulation of air flow through the incubator from the outside (Jordan 1989).

Dry-bulb temperature: 37.8°C (100°F)
Wet-bulb temperature: 29.4-30.6°C (84.9-87.1°F)
Relative humidity: 55-60%
(C Hall pers. comm.).

11.3 DESIRED % EGG MASS LOSS

The average percentage egg mass loss for rollers is 10-14% (Witman 2007). This can be controlled by adjusting the relative humidity level (i.e. by reducing the surface area of the water container within the incubator, the relative humidity is lowered, thereby increasing the rate of egg loss).

11.4 HATCHING TEMPERATURE AND HUMIDITY

Eggs are transferred to the hatcher approximately three days prior to hatching (Witman 2007).

Dry-bulb temperature: 37.5°C (99.5°F)
Wet-bulb temperature: 31.7-32.8°C (89.1-91°F)
Relative humidity: 68-70%
(C Hall pers. comm.).

11.5 NORMAL PIP TO HATCH INTERVAL

The pip to hatch interval for Dollarbirds is usually 24-48 hours, with an average of 32.26 hours (C Hall pers. comm.).

11.6 BROODER TYPES/DESIGN

There are a variety of ways to heat the chicks once they are transferred to a brooder. Commercially available brooders are ideal, as they will have a built-in heat source and thermostat. Alternatively, a simple brooder can be made by providing a heat source (such as a red bulb, heat mat or heat cord) attached to a thermostat. The type of container used will to some extent depend on the heat source, but can include a large plastic tub or hospital cages.

11.7 BROODER TEMPERATURES

The initial brooder temperature for a hatchling is 35°C (95°F). This is reduced gradually to 31.1°C (87.9°F) by day seven, then 26.6°C (79.9°F) by day 15. The brooder is then maintained at this temperature until the chicks are removed from the brooder (for more information on brooder temperatures, see Appendix 2) (C Hall pers. comm.).

11.8 DIET AND FEEDING ROUTINE

Once hatched, chicks are fed at the first sign of a feeding response, or within 12 hours (Witman 2007). As all chicks need a good source of protein to develop normally, pinkie mice and insects form the bulk of the rearing diet. Gut impactions from the indigestible chitin can be avoided in young chicks by using two week old crickets and moulted mealworms. Food should be chopped into bite-sized pieces and dipped in an oral electrolyte solution before feeding. Blunt-tipped forceps are used to place the food far back into the mouth (Witman 2007). As the chick grows, the food can be cut into increasingly larger sizes.

Table 4 summarises a feeding schedule for hand rearing Dollarbirds from hatching (for the full brooder and feeding table, see Appendix 2). Feed quantities are calculated as a percentage of the chicks body weight (grams), and then divided by the number of feeds needed for the day. At San Diego Zoo, the goal is to maintain a 15-20% daily weight gain. If the weight gain is too high, the food intake is held at the previous days percentage, or decreased by 5% (C Hall pers. comm.).

Table 4 Recommended feeding schedule for Dollarbird chicks used by San Diego Zoo (C Hall pers. comm.).

Day	Frequency of feeds	Diet (by weight)	Daily intake as % of body weight
0	Every 2 hours (x7)	100% chopped pinkie mice; with Pedialyte	25%
1	"	"	30%
2	"	"	35%
3	"	"	40%
4	"	"	45%
5-6	"	65% chopped pinkie mice; 35% 2 week old crickets; with Pedialyte	45-50%
7-8	"	40% chopped pinkie mice; 25% 2 week old crickets; 35% moulted or half mealworms; change from Pedialyte to distilled water	50%

Day	Frequency of feeds	Diet (by weight)	Daily intake as % of body weight
9	"	40% chopped pinkie mice; 25% 2 week old crickets; 35% moulted or half mealworms	"
10-13	Every 3 hours (x5)	40% chopped pinkie mice; 30% adult crickets without heads; 30% moulted or half mealworms	"
14-16	"	40% chopped fuzzie mice; 30% adult crickets with heads; 30% moulted or half mealworms	"
17-18	Every 4 hours (x4)	50% chopped fuzzie mice; 25% adult crickets with heads; 20% mealworms; 5% soaked dog food; offer live insects	"
19	"	"	Feed ad lib.
20-23	"	40% chopped fuzzie mice; 20% adult crickets; 20% mealworms; 10% soaked dog food	"
24	Every 5 hours (x3)	"	"
25-29	"	30% chopped fuzzie mice; 15% adult crickets; 15% mealworms; 15% soaked dog food	"
30-36	"	Adult diet: 45% carnivore meat; 25% chopped fuzzie mice; 20% soaked dog food; 5% adult crickets	"
37-45	Every 6 hours (x2)	"	"
46	Feed x1	"	"

11.9 SPECIFIC REQUIREMENTS

None identified.

11.10 FLIGHT RESTRAINT REQUIREMENTS

As most captive Dollarbirds are kept in large aviaries, flight restraint is undesirable.

11.11 DATA RECORDING

Routine recording of temperature and humidity readings, two to three times a day will help to identify trends in hatching and rearing success. Throughout embryo development, progress of the embryo should be monitored and recorded via candling and weighing. Eggs should be weighed twice a week.

Other useful data to record include incubation periods, pip-to-hatch intervals and any assisted hatching required (Jordan 1989). Once hatched, daily weighing of the chick (in the morning prior to the first feeding) can provide valuable data for growth development rates.

11.12 IDENTIFICATION METHODS

Individual chicks can be identified by using a nontoxic marker pen applied to the chick's feathers (usually on the top of the head). Uniquely numbered or colour coded leg bands can also be placed on the chicks for identification.

11.13 HYGIENE

Good hygiene practices during incubation and hand-rearing are essential as bacterial and fungal pathogens can be fatal to developing embryos or growing chicks. Hands should be washed with a disinfectant before eggs or chicks are handled.

During incubation

The high humidity and temperature found in incubators provide an ideal breeding ground for bacteria and fungus. Pathogens can enter the egg through the numerous pores that are present in the shell and be fatal to the developing embryo (Jordan 1989). It is good practice to wipe down the outside of the incubator weekly. The inside should be disinfected between each clutch of eggs. Floors should routinely be washed with a disinfectant (at least twice a week) (Witman 2007). The water tank/reservoir inside the incubator also needs regular cleaning. The addition of Vetafarm Aviclens to the water can reduce the growth of harmful pathogens (Jordan 1989).

During hand-rearing

Feeding implements should be soaked in Vetafarm Avi-Care between feeds. The rearing container should be wiped down regularly using a disinfectant such as Vetafarm Avi-Care, and the container bedding changed after each feed.

11.14 BEHAVIOURAL CONSIDERATIONS

Dollarbirds imprint on humans very quickly and, when mature, can potentially become aggressive to humans when around food (C Alexander pers. comm.). To prevent imprinting, chicks should be fed as quickly and efficiently as possible, and handled as little as possible. A hand puppet can be used when feeding, or alternatively 'ghost-rearing' may be used where the keepers cover

their body with a sheet and wear a sock over their hand whilst feeding (Witman 2007).

11.15 USE OF FOSTER SPECIES

The use of foster species for Dollarbirds is unknown.

11.16 WEANING

Weaning of Dollarbirds begins at about 17 days, when the food pan is left in the brooder between feedings (C Hall pers. comm.). At this stage, chicks will begin to pick at the food.

Hawking can be taught as soon as the Dollarbird start perching. Small pieces of food are thrown towards the bird until it attempts to catch them. The distance the food is thrown can be gradually increased until the bird starts to fly out towards the food (Henderson 1999).

One problem that can be encountered with hand reared Dollarbirds may occur when they are removed from their sibling group. These birds may stop eating (even though totally weaned), and have been known to lose up to 30% of their body weight. This continues until one of the following occurs:

- a. the bird is left to become familiar with it's new environment, and hopefully start feeding for itself;
- b. the bird is returned to it's sibling group;
- c. the bird is force fed.

The bird's weight should be monitored closely during this transition period (C Hall pers. comm.).

One possible reason for this occurrence relates to their wild behaviour. In the wild, young Dollarbirds will congregate in groups shortly after weaning and before migration (Higgins 1999). It is possible that separating young hand reared Dollarbirds from their siblings stresses them at a time when they would normally be surrounded by other young birds. It is not known if this problem occurs in Dollarbirds that are hand reared in isolation from other Dollarbirds.

Hand reared birds also tend to have poor waterproofing of their feathers, and thus become waterlogged in wet weather. The reason for this is unknown, although feather waterproofing does seem to improve with age (C Hall pers. comm.).

11.17 REHABILITATION PROCEDURES

Wild Dollarbirds are usually admitted to wildlife carers through injury or orphaning. On arrival, they may find it difficult to adapt to an artificial diet and may take several days to start feeding properly. It is important to check for injuries to the wings and legs, as they may have fallen from a considerable height (Henderson 1999).

Housing of injured Dollarbirds will depend on the extent of their injury and the age of the bird. Young birds or birds with serious injury requiring confinement are best housed in cages. Wire cages should be avoided, as Dollarbirds may damage their feathers on the cage bars. Cages with solid sides and a Perspex front are preferable (C Alexander pers. comm.). As the bird recovers, the size of the cage/aviary should be progressively increased to allow the bird to develop its flight muscles. Prior to release, Dollarbirds should be housed in a sizeable aviary with ample flying room. It may be necessary to place black shade cloth over the wire to ensure that the birds do not fly into the side of the aviary with too much force (Henderson 1999).

Fledglings and adults can be fed pinkie mice, crickets and mealworms as well as a supplement such as Wombaroo Insectivore or Vetafarm InsectaPro. Mince, yolk of hard boiled egg and calcium supplements can also be added to the diet. As they recover, the quantity of live food should be increased. Young birds may need to be taught how to hawk (Henderson 1999).

Prior to release, Dollarbirds should weigh approximately 120 grams. They should be feeding consistently on live insects taken on the wing and be flying strongly. Before releasing, ensure that there will be several days of fine weather. Support feeding may be required until they are ready to migrate. Release at least one month before migration (migration in Australia is usually early March) (Henderson 1999).

12. Acknowledgements

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14. Further Reading

The following references contain valuable information beyond the scope of this manual. It is recommended that they be consulted for additional information as required.

Fry, CH 2001, 'Family Coraciidae (Rollers)' in J de Hoyo, A Elliot & J Sargatal (eds.), *Handbook of Birds of the World, Vol. 6. Mousebirds to Hornbills*, Lynx Edicions, Barcelona.

This is the most comprehensive and up-to-date text on Coraciidae behaviour in the wild. Details the behaviour, social structure, breeding biology and systematics of all roller species.

Higgins, PJ (ed.) 1999, *Handbook of Australian, New Zealand and Antarctic Birds. Volume 4: Parrots to Dollarbirds*, Oxford University Press, Melbourne.

The section on Dollarbirds contains much data collected from observations of birds in the wild.

International Air Transport Association 2007, *Live Animals Regulations, 34th ed.*, IATA, Montreal.

For the complete regulations regarding transportation of live birds including transport container design, food and water requirements and species specific requirements.

Holland, G 2007, *Encyclopedia of Aviculture*, Hancock House, Canada.

Information on keeping rollers in captivity. Aviary design, diet and information on live food propagation is also covered.

Jordan, R 1989, *Parrot Incubation Procedures*, Black Cockatoo Press, Victoria.

Although written as a guide to incubating parrots, many of the principles can be applied to the incubation of Dollarbirds. Details include incubators types, egg candling, repairing of cracked shells, incubating procedures, hatching and hatching assistance, and problems commonly encountered during incubation and hatching.

Ritchie, BW, Harrison, GJ & Harrison, LR (eds.), *Avian Medicine: Principles and Application*, Wingers Publishing Inc. United States.

This is the most comprehensive text on all aspects of captive avian medicine.

15. Glossary

browse cuttings Cuttings from shrubs and trees placed in an enclosure to provide food and/or enrichment for animals.

bumblefoot Also called pododermatitis; ulcerative infection caused by a bacteria on the underside of the foot.

candling Process of shining a very bright light (such as a torch) through an egg to observe whether an egg is fertile as indicated by the presence of blood vessels.

crepuscular Used to describe animals that are active during dawn and dusk.

gut loading Describes the feeding of insects an artificial diet comprising the vitamins and minerals needed by the animal that the insects will be fed to.

hawking A feeding technique whereby a bird will catch prey (usually insects) during flight, then either consuming it in mid-air or first returning to the perch before eating.

laparoscopy A medical procedure whereby a small incision is made in the abdominal wall, and a laparoscope is inserted allowing the practitioner to examine the abdominal cavity for diagnosis of disease or to view the reproductive organs for sex determination.

meating-off Process of converting a wild insectivorous bird to an artificial diet. Involves dipping live insects into a nectar or honey solution, then rolling them in an insectivore powder. Over time, the new bird will grow accustomed to the taste of the artificial food, which can then form the bulk of the diet.

pre-basic moult A full pre-basic moult is the complete replacement of body and flight feathers, which many birds undergo annually. A partial pre-basic moult involves replacement of all feathers except the remiges, retrices and greater

remiges The long flight feathers of the wing.

retrices The tail feathers.

subclinical Non-visible.

upper-wing coverts The feathers that overly the remiges on the wing.

Zugunruhe Also called 'migratory restlessness', used to indicate behaviour exhibited in captive birds during the time when wild conspecifics are migrating. Behaviour exhibited often involves the bird orienting itself towards the direction of migration and wing fluttering.

16. Appendix

Appendix 1. Additional taxonomic and anatomical characteristics of Dollarbirds (Higgins 1999).

Characteristic	Comments
Head	large and broad; crown flat.
Bill	stout and very broad at the base; slightly hooked at the tip with a few rectal bristles.
Nostrils	horizontal slits about 10mm long; set back on the bill mostly covered by feathers.
Neck	short; 13-14 cervical vertebrae.
Uropygial gland	bi-lobed; naked
Wings	paddle-shaped at the tip; 11 primary feathers (p9 the longest with p10 5-13mm shorter); 15 secondary feathers; diastataxic (no secondary feather corresponding to the fifth greater wing covert feather).
Tail	12 rectrices; usually slightly forked, but sometimes square; t5 or t4 longest; t1 shortest.
Tarsus	short; syndactylous feet; all three toes fused at the basal joint approximately one third along the length of the middle toe; front of tarsus and toes scutellate; hind tarsus and bottom of toes granulate.

Appendix 2. Hand rearing record for Dollarbirds reared at San Diego Zoo (C Hall pers. comm.).

San Diego Zoo Avian Propagation Centre: Chick Notes

Species: Eastern Dollarbird

The goal is to maintain a 15-20% daily weight gain.

If weight gain is too high, hold at previous day's % intake, or decrease by 5%.

Day	Brooder Temp . [°C (°F)]	Brooder	Frequ-ency of feeds	Diet (by weight)	Intake as % of body weight	Misc. comments
0	35.0 (95)	In nest cup w/ tissue in AICU w/ water pan for humidity; 26.6-27.7°C (80-82°F) wet-bulb	Every 2 hours (x7)	100% chopped pinkie mice; with Pedialyte	25%	Betadine ys seal 2x/3 days; CaCO 2 nd or 3 rd feeding; feed on scale; goal 15-20% wt gain/day
1	34.5 (94)	"	"	"	30%	Apetate at 1ml/50g food
2	33.8 (93)	Add Nomad matting to nestcup	"	"	35%	"
3	33.3 (92)	"	"	"	40%	"
4	32.7 (91)	Keep brooder covered; dark to simulate nest cavity until feeding	"	"	45%	"
5	32.2 (90)	"	"	65% chopped pinkie mice; 35% 2 week old crickets; with Pedialyte	45-50%	"
6	31.6 (89)	"	"	"	"	"
7	31.1 (88)	"	"	40% chopped pinkie mice; 25% 2 week old crickets; 35% moulted or half mealworms; change from Pedialyte to distilled water	50%	"
8	30.5 (87)	"	"	"	"	"
9	30.0 (86)	Remove water pan	"	40% chopped pinkie mice; 25% 2 week old crickets; 35% moulted or half mealworms	"	Note when begins casting pellets

Day	Brooder Temp . [°C (°F)]	Brooder	Frequency of feeds	Diet (by weight)	Intake as % of body weight	Misc. comments
10	29.4 (85)	"	Every 3 hours (x5)	40% chopped pinkie mice; 30% adult crickets without heads; 30% moulted or half mealworms	"	"
11	28.8 (84)	"	"	"	"	"
12	28.3 (83)	"	"	"	"	"
13	27.7 (82)	"	"	"	"	"
14	27.2 (81)	"	"	40% chopped fuzzie mice; 30% adult crickets with heads; 30% moulted or half mealworms	"	Change to dicalcium phosphate
15-16	26.6 (80)	"	"	"	"	"
17-18	"	"	Every 4 hours (x4)	50% chopped fuzzie mice; 25% adult crickets with heads; 20% mealworms; 5% soaked dog food; offer live insects	"	Leave food pan in between feedings with light on
19	"	"	"	"	Feed ad lib.	"
20-23	"	"	"	40% chopped fuzzie mice; 20% adult crickets; 20% mealworms; 10% soaked dog food	"	"
24	"	"	Every 5 hours (x3)	"	"	"
25-26	"	"	"	30% chopped fuzzie mice; 15% adult crickets; 15% mealworms; 15% soaked dog food	"	"
27	"	Move to covered Howdy cage with heat	"	"	"	27-33 Begin weaning perching
28	"	Outside open Howdy during day	"	"	"	"
29	"	"	"	"	"	Watch for 'fledge'

Day	Brooder Temp . [°C (°F)]	Brooder	Frequency of feeds	Diet (by weight)	Intake as % of body weight	Misc. comments
30-34	"	"	"	Adult diet: 45% carnivore meat; 25% chopped fuzzie mice; 20% soaked dog food; 5% adult crickets	"	Delete Apetate and calcium
35-36	"	"	"	"	"	Self-feeding may occur 'easiest' at 55g (day 35-40); discontinue mid hand feed
37-45	"	Outside day and night with heat at night	Every 6 hours (x2)	"	"	"
46	"	"	Feed x1	"	"	"

Note: Apetate Vitamin B supplement: use 1cc/50gm food fed
Calcium carbonate: use 1% of amount fed previous day
Dicalcium phosphate: use 1% of amount fed previous day

Appendix 3. Product manufacturers mentioned in the text.

Product	Manufacture/Distributor	Comments
Apetate Liquid B-Complex Vitamin	Bradley Pharmaceuticals Inc. Fairfield, NJ, USA < http://www.bradpharm.com >	Children's vitamin B liquid used in the hand-feeding of chicks.
Betadine	Symbion Health Limited 55 Kirby Street Rydalme, NSW 2116 < http://www.betadine.com.au >	Antiseptic iodine solution.
Brooder: Kimani Brooders	Kimani Aviaries P.O. Box 605 Kalamunda WA 6076 < http://www.kimani.com.au >	A large variety of different brooders available to suit all types of birds.
Dollarbird Nest Boxes	The Australian Nest Box Company 81 Haig St Gordon Park QLD 4031 < http://users.bigpond.net.au/ozbox/index.htm >	Manufacturers of a wide range of nest boxes for native wildlife.
Hagen Pet Cargo Carrier	Australian Importer: Pet Pacific Pty Ltd 46 David Road Emu Plains NSW 2750 < http://www.petpacific.com.au >	Available in various different sizes to suit. IATA approved.
Heat lamps; heat mat; heat cord; thermostats; thermometers	Ultimate Reptile Supplies P.O. Box 11 Enfield Plaza, Enfield SA 5085 http://www.ultimatereptiles.com.au/	Supplier of heat lamps, bulbs, heat mats and heat cord, as well as a wide range of thermostats and thermometers.
Iams Weight Control for Dogs	Iams Australia/New Zealand Pty Ltd PO Box 6116 Frenchs Forest NSW 1640 < http://www.iams.com >	Dog kibble commercially available for overweight dogs (low in calories). Used in food mix for Dollarbirds.
Incubator: Kimani Fan-force Incubator	Kimani Aviaries P.O. Box 605 Kalamunda WA 6076 < http://www.kimani.com.au >	Supplier of fan-forced incubators with either manual or automatic egg turning.
Live insects and frozen mice	Pisces Enterprises P O Box 200 Kenmore QLD 4069 < http://piscesenterprises.com >	A range of foods are available including crickets, mealworms, waxworms and frozen mice.
Marion Zoological Insect Supplement	Marion Zoological 2003 E. Center Circle Plymouth, MN 55441, USA < http://www.marionzoological.com >	Commercial manufacturer of high calcium cricket diets
Natural Balance Zoo Carnivore 5 Diet	Dick Van Patten's Natural Balance Pet Foods, Inc. 12924 Pierce Street, Pacoima, California 91331, USA < http://www.naturalbalanceinc.com >	Specifically developed for carnivores, but also used for insectivores.
Nomad Matting	3M AUSTRALIA 950 Pacific Hwy Pymble, NSW 2073 < http://www.3m.com.au >	Vinyl looped matting used for the base of brooding cups.

Product	Manufacture/Distributor	Comments
Nekton Tonic I Supplement	Guenter Enderle Enterprises Inc. NEKTON-PRODUKTE 2340 State Road 580, Suite E USA - Clearwater, FL 33763, USA < http://www.nekton.de >	NEKTON-TONIC-I is suited to the dietary requirements of insectivorous birds.
Pal Pedigree Puppy	Mars Australia 1 Petcare Pl, Wodonga VIC 3689 < http://www.pedigree.com.au/ > < http://www.mars.com >	A high energy, small biscuit manufactured for puppies. Used in food mix for Dollarbirds.
Pedialyte	Abbott Australasia Pty Ltd 32 - 34 Lord Street, Botany NSW 2019 < http://www.abbottlabs.com.au > < http://pedialyte.com/ >	Pedialyte is an oral electrolyte solution that is specifically designed to replace fluids and minerals (electrolytes) that are lost in children. Used when hand feeding chicks.
Vetafarm Avi-Care	Vetafarm 3 Bye St Wagga Wagga NSW 2650 < http://www.vetafarm.com.au >	Disinfectant suitable for hospital cages, food and water containers, hand rearing equipment and preparation areas, incubators, brooders, perches, nest boxes and for general use in companion animal housing and environs.
Vetafarm Aviclens	As above	Reduces the contamination of water by algae, fungi and yeasts in water containers.
Vetafarm Calcivet	As above	Liquid Calcium and Vitamin D3 supplement for birds.
Vetafarm D'Nutrical	As above	D Nutrical is designed to add approximately 0.76% calcium to the feed when used as directed. It will also supply a broad range of vitamins and minerals that may be lacking in prepared feeds.
Vetafarm Insecta-Pro	As above	Complete Live Food replacement. High specification extruded protein food suitable for all insectivores (except toucans and Indian Mynars).
Vetafarm Soluvet	As above	A high potency Vitamin supplement designed by avian Veterinarians for all species of birds.
Wombaroo Insectavore	Wombaroo Food Products PO Box 151 Glen Osmond SA 5064 < http://www.wombaroo.com.au/ >	A complete food for rearing or supplementing the diet of insectivorous or carnivorous birds.
Wombaroo Parrot Crumbles	As above	Maintenance food for birds containing all essential nutrients in a balanced formula.