

BUSH STONE-CURLEW (*Burhinus grallarius*)
HUSBANDRY MANUAL

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Status: Threatened Taxon, Schedule 2 Flora and Fauna Guarantee Act 1988
(M^cCulloch, 1998)
Rare in Australia (M^cCulloch, 1998)
Endangered in New South Wales and South Australia (Stanger *et.al.*, 1998)
Vulnerable in Victoria (Stanger *et.al.*, 1998)
Common in Queensland (Nature Conservation Act 1992)

ASMP Category 4

Species Coordinator: none



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1 TAXONOMY

1.1 Nomenclature

Class:	Aves
Order:	Charadriiformes
Family:	Burhinidae
Genus & Species:	<i>Burhinus grallarius</i>

It is important to note that at present, the bush stone-curlew is entered under the scientific name *Burhinus magnirostris* in all ISIS created programs (ie. ARKS, SPARKS).

1.2 Subspecies

Although subspecies were once recognised (Meinertzhagen, 1924; Lane, 1987), today, despite birds in the northern region having paler plumage than those of the south, these subspecies are no longer in use (Marchant & Higgins, 1993).

1.3 Other Common Names

The bush stone-curlew is also known as the bush thick-knee (due to the swelling of the tibiotarsal joint of the leg), southern stone curlew, southern stone plover, Weeloo or Willaroo.

2 NATURAL HISTORY

Members of the family Burhinidae occur on all continents of the world except North America and Antarctica (Pringle, 1987). Presently the family consists of nine species in two genera: *Burhinus* with five species in the Old World and two in the Neotropical region, and *Esacus* with two species, one in each of Australasia and south-east Asia (Cramp, 1983; Sibley & Munroe, 1990; Marchant & Higgins, 1993). Australia is the home to one species in each genera - *Burhinus grallarius*, the bush stone-curlew, and *Esacus magnirostris*, the slightly larger beach stone-curlew (known as *Esacus neglectus* throughout ARAZPA). Fossils from members of the Burhinidae from the Miocene age (5-24 million years ago) have been found at Lake Eyre and Lake Tarkarooloo in north-eastern South Australia, showing that Australia has been home to this family for a long time (Rich & Baird, 1986).

The bush stone-curlew has long been held in captive institutions throughout Australia, with the earliest recorded captive breeding of the species reported in 1960. It is an unusual bird species with its nocturnal habits, but still displays well throughout the day, and is therefore a popular display species. A species update and recommendation by Peter Myroniuk in 1989 described the holding of 87 individuals in 15 institutions at that time, and a total of 125 individuals listed in the studbook report. Although it is known that the bush stone-curlew is a very long-lived species, there has been little research collected in either the field or captivity, therefore opening the way for a great deal of research.

2.1 Morphometrics

The weights and basic morphological measurements published to date for the bush stone-curlew are listed below (Table 1). Clinal and geographical variations (Bergmann's Rule¹, Mayr, 1963; Allen's Rule², in Schodde & Mason, 1980) often lead to the evolution of slightly variable morphologies. In bush stone-curlews, northern individuals are believed to be slightly

¹ Bergmann's Rule – the idea that the size of homoiothermic animals in a single, closely related, evolutionary line increase along a gradient from warm to cold temperatures.

² Allen's Rule – that a race of warm-blooded species in a cold climate typically has shorter protruding body parts relative to body size than another race of the same species in a warm climate.

smaller than individuals in the south, but disproportionately longer in the leg and bill (Marchant & Higgins, 1993). Using measurements from specimens around the country, Andrews (1997) found no support of these rules, however, does acknowledge a small sample size and the possibility of incorrect sexing of museum specimens.

Table 1: Weights and morphological measurements of the bush stone-curlew published in literature.

Weight (g)	Head/bill (mm)	Bill (mm)	Tarsus (mm)	n	Reference
658±155 (480-900)	105±4 (91-115)	54±3 (40-62)	130±11 (98-150)	118	Andrews (1997)
-	-	43-53	112-145	-	Hayman <i>et al.</i> , (1986)
570-810	-	-	108-147	60	Schodde & Mason (1980)
580-810	-	42-54	116-147	-	Pringle (1987)
625-670	-	46-61	109-143	4-11	Marchant & Higgins (1993)

In many species of birds, including the bush stone-curlew (Schodde & Mason, 1980), the plumage and size of the male and female are very similar, making it impossible to distinguish confidently between the sexes (Lessells & Mateman, 1996). Although some believe plumage and size is sex related in stone-curlews, to date there is no known way of externally sexing bush stone-curlews accurately (Hayman *et al.*, 1986; Marchant & Higgins, 1993). Andrews (1997) developed two equations based morphological measurements from known sex birds, as stated below, but it is important to remember that this sexing method is only to 80% accuracy.

(a) from five morphological measurements; or

(b) from two morphological measurements

For either (a) or (b), the sex equation with the highest resultant discriminant score (discrim. sc.) is the more likely sex of the bird.

(a) Female

$$\text{discrim. sc.} = 0.225x_{\text{bill}} + 3.225x_{\text{head}} + 0.563x_{\text{tail}} + 1.958x_{\text{tarsus}} - 0.006x_{\text{wing}} - 263.623.$$

Male

$$\text{discrim. sc.} = 0.242x_{\text{bill}} + 3.354x_{\text{head}} + 0.582x_{\text{tail}} + 2.100x_{\text{tarsus}} - 0.006x_{\text{wing}} - 293.504.$$

(b) Female

$$\text{discrim. sc.} = 3.606x_{\text{head}} + 1.828x_{\text{tarsus}} - 207.040.$$

Male

$$\text{discrim. sc.} = 3.742x_{\text{head}} + 1.968x_{\text{tarsus}} - 232.263.$$

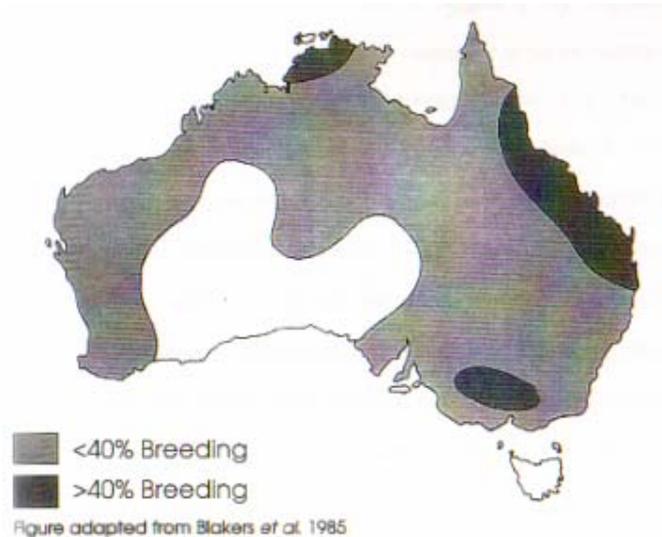
As there appears to be no 100% accurate external sexing methods thus far, the best methods for determining the sex of a bush stone-curlew is by laparoscopy, or by taking a blood sample and identifying the presence or absence of a W chromosome (the female chromosome in birds) in the DNA. This is most often done by a genetics laboratory at a university, with W chromosomes for bush stone-curlews having previously been identified by Dr Mike Double at the Australian National University.

2.2 Distribution

Although the *Burhinus* genus is worldwide, the bush stone-curlew is endemic to Australasia. Once common throughout the open woodland regions of Australia, by 1900 the bush stone-curlew had become extinct in Tasmania (Blakers *et al.*, 1985; Lane, 1987; Pringle, 1987), and by 1930 it had all but vanished from built-up areas. Today the species is rare in the south eastern, eastern and western regions of the country, and absent or scattered inland, remaining common only in parts of Queensland and the Northern Territory (Pringle, 1987; Marchant &

Higgins, 1993)(Fig. 1). It is also known to exist on many off-shore islands, including Melville, Groote, Kangaroo, Magnetic and many Whitsunday Islands (Schodde & Mason, 1980; pers. obs). In 1968 the bush stone-curlew was found to occur in *Melaleuca* areas of southern New Guinea (Lindgren, 1971). Although the stone-curlew is recorded to be able to fly distances, it is not a migratory species.

Figure 1: The distribution of the bush stone-curlew in Australia



2.3 Habitat

The bush stone-curlew inhabits lightly-timbered open forest and woodland, with a ground covering of sparse grass and few, if any, shrubs (Schodde & Mason, 1980; Marchant & Higgins, 1993). It has, however, been found in a variety of other habitats, including dry open grasslands, mangroves, saltmarsh and croplands, but rarely on beaches and dunes, rainforest and heavy forest (Schodde & Mason, 1980; Hembrow, 1988; Sibley & Munroe, 1990; Marchant & Higgins, 1993).

2.4 Wild diet and feeding behaviour

The bush stone-curlew is a nocturnal bird which feeds mainly on invertebrates, such as insects, crustaceans, arachnids and molluscs, but will also feed on frogs, reptiles and even small mammals (Schodde & Mason, 1980; Marchant & Higgins, 1993). Occasionally it will also feed on seeds, fruit and vegetation (Blakers *et al.*, 1985; Lane, 1987; Pringle, 1987; Marchant & Higgins, 1993). Although the bush stone-curlew will feed opportunistically, it generally feeds throughout the night.

2.5 Longevity

The bush stone-curlew is known to live for approximately thirty years (M^cGilp, 1947 in Schodde & Mason, 1980), and is believed to hold life-time pair-bonds (Flavell, 1992), although trios do occur (Andrews, 1997). Long term bonds in birds have been found to increase breeding success of both males and females (Coulson, 1966; Oring & Lank, 1982).

3 HOUSING REQUIREMENTS

3.1 Exhibit design

The nocturnal bush stone-curlew is described as a slow moving and placid species that is ideally suited to a large aviary (Nagel, 1983; Shephard, 1994). It is generally not an excitable bird, but even if it does fly, it is unlikely to injure itself. For this reason, the stone-curlew is regularly seen in large, often walk-through aviaries, generally resembling the woodland habitat that the stone-curlew naturally inhabits. Stone-curlews require nesting sites of little ground-cover, with grasses no higher than 25cm, and preferably 5cm (Green & Griffiths, 1994) and fallen tree debris (Johnson & Baker-Gabb, 1994). This provides the bird with good ground vision for detection of threats, the necessary camouflage when incubating, and an environment suitable for invertebrates (the primary wild food source)(Andrews, 1997). As stone-curlews are territorial birds, when in larger numbers, there needs to be adequate room for the individual bird to be protected from dominance and conflict by conspecifics, and to provide for its physical and behavioural well-being. The bush stone-curlew has also been known to display well in nocturnal houses. The exhibit also needs to be constructed as such that it protects the stone-curlew from harassment by the viewing public.

3.2 Holding area design

The bush stone-curlew is not an active bird when food is supplied (as in captivity), and therefore is comfortable being held in an aviary approximately 4m x 5m in size. Providing there is enough shelter from the sun and rain in the form of vegetation or a man-made covering, the bush stone-curlew will spend the majority of the time lying down. The bush stone-curlew rarely flies, so height in the aviary is needed only for human access, unless the aviary will be used to house arboreal species.

3.3 Position of enclosures and weather protection

The positioning of enclosures for the bush stone-curlew is not the most important issue when building structures for this species, as these birds are often displayed in large walk-through aviaries that are going to be exposed to all climatic conditions. What is of more importance is sheltering from the elements at the correct locations within the aviary. This is best provided with either the correct vegetation or artificial roofing or panels over the weather affected parts of the aviary. When stone-curlews are housed in smaller aviaries, such as holding aviaries, these should be positioned with a northerly or easterly aspect to take advantage of morning sun, winter sun and summer shade, and to minimise the effects of afternoon summer sun and cold winter winds and rain (Shephard, 1994).

3.4 Substrate and enclosure furnishings

As indicated above, the bush stone-curlew requires nesting sites of little ground-cover, with grasses no higher than 25cm, and preferably 5cm (Green & Griffiths, 1994) and fallen tree debris (Johnson & Baker-Gabb, 1994). This provides the bird with good ground vision for detection of threats, and the necessary camouflage when incubating. In most zoological institutions, the most commonly used substrate in enclosures for stone-curlews is mulch or woodchips, planted with low-level tussocks and middle to top-level shrubs to provide shade and shelter. A small pond can be provided for bathing, and Shephard (1994) suggests a dry sandy area for daytime rest.

3.5 Spatial requirements

At present there is no set or standard spatial requirements set out by the Department of Natural Resources and Environment, Victoria for the housing of bush stone-curlews, however other states may require specific housing areas per individual bird. From experience, an aviary approximately 5m x 4m in size is adequate for the long-term housing of a single bird. It must be noted, however, that stone-curlews in captivity have usually been observed during the day, and as they are a nocturnal bird, behaviour may drastically change during the night. As the number of individuals increases, the aviary will need to increase, as stone-curlews are territorial, and will require the space for individual territories without feeling confined.

3.6 Interspecific compatibility

The bush stone-curlew is described as a placid species, and can therefore be housed with fruit bats and many species of birds, including pigeons, parrots, plovers, honeyeaters, bowerbirds and cuckoo-shrikes. As the stone-curlew is a terrestrial bird, it could possibly be housed with arboreal mammals also. It must be remembered that the stone-curlew will eat small reptiles, mammals and amphibians and other birds, so avoid housing them with small terrestrial species from any of these groups. The bush stone-curlew has been observed catching and eating healthy red-browed finches (*Neochmia temporalis*)(D. Carr, *pers. com*) and stalking ducklings when housed with waterfowl (P. Courtney, *pers.com*).

4 RECORD KEEPING

4.1 Daily records to be kept

As for any animal in captivity, the daily upkeep of records ensures better and more efficient management of any species. Records for bush stone-curlews do not differ greatly from those kept for any other animal, and more specifically for any other bird. Records should include:

- births or acquisitions
- deaths or disposals
- breeding attempts and/or successes
- transfers within or between establishments
- banding or identification marking
- physical condition (eg. weight, moult, morphological measurement)
- medical procedures
- behaviour
- animal management of any kind
- miscellaneous notes deemed important

4.2 Identification methods

As has been practised for many years now, the best method of bird identification is by the use of leg bands. When banding any bird, it is important to ensure that the correct sized band is being used, and that an experienced bander is performing the procedure. The wrong sized band or a band put on incorrectly can cause serious harm to a bird's leg (*pers. obs*). Both metal and colour plastic bands are suitable for bush stone-curlews, being placed on the tarsus. Plastic colour bands can be placed on the tibia of stone-curlews to allow identification if the ground vegetation obscures bands at ground level. It is important to note that metal bands should not be placed on the tibia as they are known to cut into the tibiotarsal joint.

Long legs on birds such as the bush stone-curlew allow multiple bands to be placed on each leg, thereby increasing the colour combinations available, and in turn the number of birds that can be banded for visual identification.

Dependant on the number of stone-curlews within a collection, or the skill of the people involved with the birds, bush stone-curlews can also be individually identified by colour and markings.

Although not yet common in the identification of birds, and at a much greater expense, is the use of PIT (passive integrated transponder) microchips. These can be inserted into the pectoral muscle of the bird, but of course do not allow for identification by observation.

5 HANDLING AND TRANSPORT

5.1 Timing of capture and handling

Due to the nocturnal habits of the bush stone-curlew, this species tends to be quiet during the day. The bush stone-curlew becomes more active at dusk, with activity extending throughout the night until dawn. For this reason, this species of bird is best caught during the day, however, due to the quiet nature of this species, capture at any time is possible with little problem.

5.2 Catching bags

Bush stone-curlews will sit comfortably in a pillow-case sized bag, ensuring their legs are folded neatly underneath the bird, and the wings folded against the bird's body.

5.3 Capture and restraint techniques

The bush stone-curlew will rarely fly, making it a comparatively easy bird to catch. Bush stone-curlews tend to lie perfectly still against camouflaged the ground when under threat, making it easy to slowly approach them and either place a net over the bird, or by grasping the bird directly. Nesting stone-curlews can generally be caught by lifting them off the nest, as they will often remain on the nest even under threat. If the stone-curlew cannot be caught when lying in camouflage, they are an easy bird to walk along a fence-line into a smaller holding aviary or awaiting net. It is important to be careful of the stone-curlews' long, thin legs, as they can be injured in a poorly carried-out catch-up.

Once caught, the bush stone-curlew is best restrained by ensuring the wings are secured to the side of the body. It may be necessary to wrap a towel or another bag around the body to ensure the wings are secured in place, and not able to flap. They are generally not a very stressful bird, and will sit peacefully if they are unable to flap their wings or kick their legs. It is important that the stone-curlew is not left with its legs folded for too long, as this can restrict blood flow to the legs and cause temporary paralysis. If the bird is to be restrained for any length of time, the stone-curlew will behave quietly with its legs allowed to hang, though it may kick occasionally, as long as the wings are secured properly.

5.4 Weighing and examination

As the bush stone-curlew can be awkward to weigh by itself, it is probably best to weigh them within a bag or wrapped in a towel, and then to subtract the bag/towel weight from the gross weight.

When examining the bird, it is best restrained as described above. If a wing needs to be extended for examination, this can be done by holding one wing and the body in one hand, while using the other hand to extend the second wing. Wing examination is more easily done if there are two people present for the examination. If a serious or medical examination is required, it will probably be performed under anaesthetic.

5.5 Release

When releasing a stone-curlew back into an aviary or holding facility, it is best done by ensuring that the legs are tucked up under the bird's body. The bird can then be lifted out of the bag or unwrapped from the towel and placed on the ground. This allows the bird to stand up and move away at its own will, and ensures that the stone-curlews legs do not get entangled in the bag.

5.6 Transport requirements

5.6.1 Short transport periods

For transport over very short distances (such as between exhibits/enclosures or from exhibit to surgery), the bush stone-curlew will travel well in a pillow-case sized bag.

5.6.2 Long transport periods

For transport over longer periods of time, such as when transporting birds between establishments, a secure transport box must be used. As the bush stone-curlew is a large bird in that it is quite tall, it is most likely that a box will need to be specially constructed. When constructing containers for shipment of birds, the normal habits and necessary freedom of movement must be taken into account, as these birds are transported awake. The height of the compartment/container must allow the bird to stand with its neck held in a natural position, but not fully extended, and the width of the container must allow the bird to sit/lay down and turn around easily

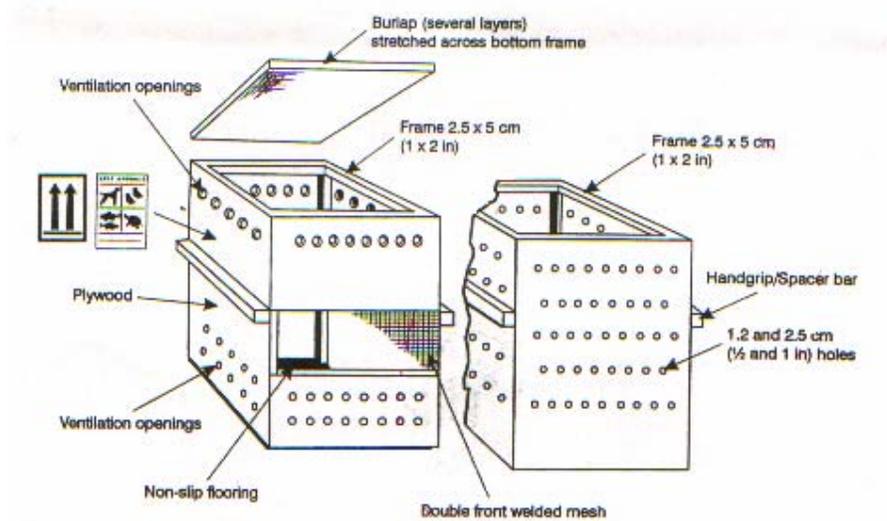
5.6.2.1 Box design

Transport box design should follow that documented in the International Air Transport Associations Live Animal Regulations (1998). This is particularly important for international shipments. The container must be well constructed, and made from non-toxic materials. The container must be suitable to keep the bird within at all times, and protect the bird from unauthorised access with accidental opening from the inside or outside impossible.

The transport box must not allow the bird to damage itself in any way, with all inside edges being rounded or smooth. The container must be leak proof and clean, with the floor of the container covered in something that allows easy cleaning. The box must be fitted with handles to allow for easy transportation, and most importantly, adequately ventilated. IATA specify *Container requirement 11H* for curlews, although the 'large wader' container (17) is preferable. For specific design requirements, refer to IATA (1998) *Container requirement 17*, but for basic transport box design, see Figure 2.

Although IATA gives the option of ventilation via wire mesh or holes drilled through the wood, stone-curlews have been known to get their toenails caught in the wire mesh and rip them out, even during short journeys (D. Carr, *pers. com.*).

Figure 2: IATA recommended basic box design for the shipment of bush stone-curlews.



5.6.2.2 Furnishings

The bush stone-curlew is not a perching bird, and therefore the only furnishings required are food and water troughs.

5.6.2.3 Water and food

For long distance travel it is important that the bird be supplied with water throughout the journey. The best food to provide for long distance travel for bush stone-curlews is either mealworms or chopped pieces of pet health loaf. It is important, however, that if sending the bird overseas that the provided food does not contravene the import regulations of the receiving country, or of any country of transit.

5.6.2.4 Animals per box

For transportation of bush stone-curlews over any distance, only one bird can be placed in each box or compartment. This is of particular importance with long-legged birds, as they have the potential to get tangled with other individuals in such a small place, causing injury and stress.

5.6.2.5 Timing of transportation

As for all animals, it is best to transport bush stone-curlews in either the early morning or late afternoon when the temperatures are lower. As stone-curlews are nocturnal, they are more quiet during the day, but will also be affected more-so by the heat. Even though they may be noisier at night, this is probably a better time for long-distance transport.

5.6.2.6 Release from the box

Bush stone-curlews are best released from the box simply by opening the door to the box and letting them exit into the enclosure in their own time. Ensure that the opening of the box and

the area directly in front of it is clear from obstacles, providing a safe area for them to enter their new environment.

6 HEALTH REQUIREMENTS

6.1 Routine treatments

The only routine treatment required for bush stone-curlews in captivity is a regular worming. Worm types and quantities are identified from regular faecal checks.

6.2 Heating requirements

No heating is generally required for bush stone-curlews in captivity. However, if youngsters are ill, or any bird is suffering from the cold or wet, it may be ideal to provide heat until the birds have reached their normal temperature. This, of course, would be in a small holding box or cage and not the exhibit.

6.3 Hygiene and cleaning requirements

As part of basic avian husbandry, it is important to ensure that food and water dishes, as well as any enclosures, are kept clean. Food and water dishes are of particular importance and must be cleaned every day. As bush stone-curlews are often housed on mulch in captivity, it is important to ensure that the mulch does not become too moist, thereby encouraging the growth of bacteria. These cleaning routines minimise any health problems that may arise from unhygienic conditions.

6.4 Known health problems

The most common health problems seen in bush stone-curlews (from veterinary records) are pneumonia and leg or foot problems. Bush stone-curlews are very susceptible to broken legs and bumble-foot in particular, with young stone-curlews often suffering from bowed legs during their first months, most likely the result of a calcium deficiency. The bush stone-curlew otherwise appears to be a sturdy bird that suffers from very few illnesses or problems, although, like any species, they are prone to many diseases and conditions.

6.5 Routine vaccinations

There really is no routine vaccination that is required by the stone-curlews, with the exception of possible worming treatments that may be administered by injection.

6.6 Routine quarantine treatments

Similar to many species of birds, the quarantine period for bush stone-curlews is 30 days. During this period at least two faecal checks should be made, and treated if necessary. There is no other routine treatment required by stone-curlews in quarantine.

6.7 Vet procedures

Other than procedures necessary for the health and well-being of the stone-curlew, as may occur in any animal, the only routine procedure may be that of surgical sexing or laproscopy. Bush stone-curlews are difficult to sex externally, and are large enough in body size that most veterinarians will feel comfortable performing this procedure.

7 BEHAVIOUR

7.1 Habits

As the bush stone-curlew is a nocturnal bird, and therefore spends much of the day resting, generally lying in camouflage amongst sticks or leaf litter. They become active at dusk, moving away from their daytime roost area to feed. They are mainly sedentary, however some birds in southern populations may be partly migratory (Pringle, 1987).

During the non-breeding months, bush stone-curlews are known to roam an area between 250 and 600 hectares in size. They form loose communal groups (Blakers *et al.*, 1985; Marchant & Higgins, 1993; Andrews, 1997) in the northern regions, feeding together over large areas. Bush stone-curlews are believed to mate for life (Flavell, 1992), and pairs or trios reform for the breeding season from July to February. During the breeding season they defend a much smaller nesting territory of approximately 1.5ha (McCulloch, 1998; Andrews, 1997), while unpaired birds remain in small groups. Andrews (1997) showed that 30% of the adult stone-curlew population on Magnetic Island, North Queensland remained in these communal groups throughout the breeding season.

During the non-breeding months of the year, stone-curlews show little aggression to conspecifics or to most other species of animals that are not deemed a threat. During the breeding season, however, stone-curlews protect their nesting territories from other stone-curlews, and their eggs or young from potential threats. A bush stone-curlew will defend its territory from other stone-curlews by emitting a high pitched rapid cry, whilst standing very erect and puffing out their chest, making themselves appear larger (Andrews, 1997). Bush stone-curlews will defend their eggs and chicks by firstly lying close to the ground and emitting a low-pitched growl. If a potential threat persists, they will either run away and appear injured, trying to distract the threat, or they will run towards the threat with their wings spread out and tail fanned, emitting the same low-pitched growl (Andrews, 1997). It is believed that stone-curlews need not protect their eggs or young from other stone-curlews, or protect their territories from any other species of animal.

7.2 Courtship

Although not often recorded, probably due to the fact that stone-curlews are thought to pair for life, and due to their nocturnal habits, it is believed that the bush stone-curlew displays a complex dance in courtship (Pringle, 1987). Terrestrial courtship has been described as whistling concerts, glee-parties, dances and corroborees, and usually involves frequent bobbing and bowing, displaying of wings and calling (Marchant & Higgins, 1993). Courtship flights involve circling and swooping, with contact of either wings and feet occasionally being made (Marchant & Higgins, 1993).

7.3 Bathing

Like any bird, the bush stone-curlew enjoys a bathe, although this is usually performed as a dust bath rather than a water bath (pers. obs.). If water is available, the stone-curlew will step in the water, flap its wings and preen.

7.4 Captive behavioural problems

Bush stone-curlews are not known to show any problems related to captivity. However, this may be due to the fact that stone-curlews are nocturnal and therefore captive birds are generally seen only in the day when they are resting. Observations of night-time behaviour would have to be completed before captive behavioural problems could be ruled out, although stone-curlews in nocturnal houses have shown few problems (S. Jackson, *pers. com*).

7.5 Behavioural enrichment activities

As stone-curlews are nocturnal, there is not a great deal that can be done to enrich behaviour during the day. Night time enrichment may be difficult as most keeping staff do not work throughout the night. However, a basic form of enrichment for bush stone-curlews might be the simple scattering of live food over the ground for them to find on their own, rather than deliver all their food in a dish.

8 FEEDING REQUIREMENTS

8.1 Captive diet

The following diet is that currently fed to bush stone-curlews at Healesville Sanctuary.

AD LIB: Water.

DAILY DIET (per animal):

<u>Breeding Season</u>	100g	Meat mix.*
	1	Mouse – chopped in half or equivalent in small mice
	25g	Mealworms ½ AM and ½ PM.

<u>Non-Breeding Season</u>	100g	Meat mix.*
	1	Mouse – chopped in half or equivalent in small mice
	10g	Mealworms ½ AM and ½ PM.

* meat mix – 25g Ecopet Pet Health Loaf (lamb & vegetable) 5kg (2 loaves)
6 grated hard boiled eggs
200g grated cheese
200g fly pupae

It is important to ensure that adults birds raising chicks are given adequate amounts of live food to feed to the young. There have been reports that adults with inadequate supplies of live food have fed chicks leopard slugs, leading to the untimely death of the chick (Manning, *pers. com.*)

8.2 Presentation of food

The meat mix is best presented in a dish or tray on the ground. Depending on the individual stone-curlews, the mice can either be thrown on the ground if the bird is to eat it straight away, otherwise it may be best to present the mouse within the tray. Mealworms are ideal to throw directly onto the ground, as this gives the stone-curlew something to do, rather than just eating straight from the dish. Some people prefer to feed stone-curlews in the afternoon, as they are a nocturnal bird, whereas others will feed them in the morning along with other birds.

9 BREEDING

During the non-breeding months, bush stone-curlews are known to form loose communal groups (Blakers *et al.*, 1985; Marchant & Higgins, 1993), feeding together over large areas. Bush stone-curlews are believed to mate for life (Flavell, 1992), and pairs or trios reform for the breeding season from July to February, with unpaired birds remaining in small groups (Andrews, 1997).

The nest is a scrape in the ground, into which generally two camouflaged eggs are laid. After an incubation period of 22-30 days (Lane, 1987; Anderson, 1991; Schodde & Mason, 1990; Marchant & Higgins, 1993), the precocial (where chicks are well developed at hatching), nidifugous (those that leave the nest within a day or two of hatching) chicks hatch, and within 1-2 hours are led away from the nest site. The young remain with their parents for 47 to 138 days (Pringle, 1987; Marchant & Higgins, 1993), allowing the breeding pair to nest again if the first clutch has been laid early in the season (Schodde & Mason, 1980). Both parents participate in the incubation and care of the young, as well as in the defence of the nesting territory (Andrews, 1997).

9.1 Breeding system

Mating systems differ not only between species, but within species in relation to food availability (Davies, 1991; Davies & Lundberg, 1985). Bush stone-curlews are generally regarded as exhibiting a socially monogamous mating system (Schodde & Mason, 1980). Nevertheless, it has been suggested that bush stone-curlews display variable social systems e.g. three individuals at a nesting site; in other areas of Australia (Johnson & Baker-Gabb, 1994), as have stone-curlews in other parts of the world, such as *B. oedicephalus* (Cramp, 1983). Andrews (1997) showed bush stone-curlews on Magnetic Island, Queensland to exhibit variable breeding systems. Social monogamy appeared to be the primary mating system, with multiple-clutching (where the female lays more than one clutch), polygyny (where the male has more than one female mate), 'facultative' (opportunistic) cooperative breeding (a monogamous pair and a variable number of related, non-breeding juveniles) and adoption of unrelated young (that in turn help in the raising of a pair's own young) also being exhibited.

9.2 Age at first breeding and last breeding

From Healesville Sanctuary's captive management records, it is apparent that the bush stone-curlew can breed from as young as one year of age, but more often first breeding is at two years of age. There is no documentation of age at first breeding for wild stone-curlews, but anecdotal evidence suggests wild stone-curlews first breed at two years of age. Stone-curlews have been reported to mate for life (Flavell, 1992), thereby indicating that they continue to breed until they die, which can be up to 30 years.

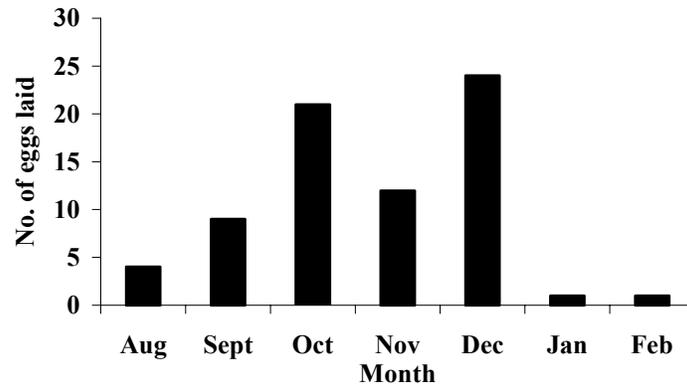
9.3 Ability to breed every year

Captive management records and field research projects (Johnson & Baker-Gabb, 1994; Andrews, 1997) indicate that bush stone-curlews can breed every year, provided the necessary resources (ie nesting sites and food) are available.

9.4 Timing of breeding

The breeding season for wild bush stone-curlews is reported as extending from July through to February, however the season has been shown to extend into March (Andrews, 1997). Furthermore, there is record of bush stone-curlews breeding all year round (Simpson & Day, 1989), although this may be a response to the patterns of food abundance. A peak in the pairing of a wild population has been shown to occur in January (Andrews, 1997), whilst in captivity, records show two peaking periods within the breeding season, due to the regular occurrence of multiple-clutching in captive birds (Fig 3).

Figure 3: Captive breeding of bush stone-curlews, indicated by the laying of eggs. Note the double peak periods.



9.5 Ability to breed more than once per year

Bush stone-curlews can breed more than once in each breeding season, in both the wild (Andrews, 1997) and in captivity. Stone-curlews do not necessarily need to lose a young to induce them to breed a second, and even third, time within a season. Andrews (1997) showed a number of instances where stone-curlews raised two clutches to fledgling age, however this may occur more often in the tropics where the season appears to be slightly longer than in temperate regions. It was also shown that on occasion, young from the first clutch aid in the defence of the nest site for the second clutch (Andrews, 1997). Captive stone-curlews have been recorded to lay up to four clutches within a season, however not all of these clutches resulted in fledgling-aged young. It is appropriate to assume that stone-curlews in captivity will breed more often due to an increase in food and available nesting sites.

9.6 Breeding diet

There is no additional food for bush stone-curlews during the breeding season other than to increase the proportion of live food in their diet. Johnson & Baker-Gabb (1993) showed that diet varied little in the wild throughout the seasons, while Andrews (1997) showed that overweight, as well as underweight, birds did not breed as successfully as birds in 'good' condition. It may be important to increase the amount of calcium in the stone-curlews' diet prior to the breeding season, as this is important in not only strengthening the egg shell, but also may help to avoid leg problems that often occur in chicks.

9.7 Gestation or incubation period

The bush stone-curlew has an incubation period of 22-30 days (Lane, 1987; Anderson, 1991; Schodde & Mason, 1990; Marchant & Higgins, 1993).

9.8 Clutch size

The normal clutch size for the bush stone-curlew is two (Maclean, 1972), however the laying of only one egg per clutch has been noted regularly. Bush stone-curlews are known to 'egg dump' or to share nesting sites, in which case there may be three or four eggs in a scrape. It is generally easy to pick the eggs that belong to each female, as each individual female produces eggs that are of a particular speckled colour which differs from those of any other female (Andrews, 1997).

Table 2: Comparison of egg size from previous studies.

Egg Length (mm)	Egg Width (mm)	n	Reference
56.1 - 58.9	38.5 - 39.0	2	Anderson (1991)
54.9 - 57.0	39.0 - 40.2	5	Andrews (1997)
51.1 - 61.2	38.4 - 40.9	6	Campbell (1974)
51.6 - 60.5	38.1 - 43.2	17	Marchant & Higgins (1993)
58.0	39.0	1	Pringle (1987)
48.0 - 64.0	34.0 - 45.0	122	Schodde & Mason (1980)

9.9 Age at fledging

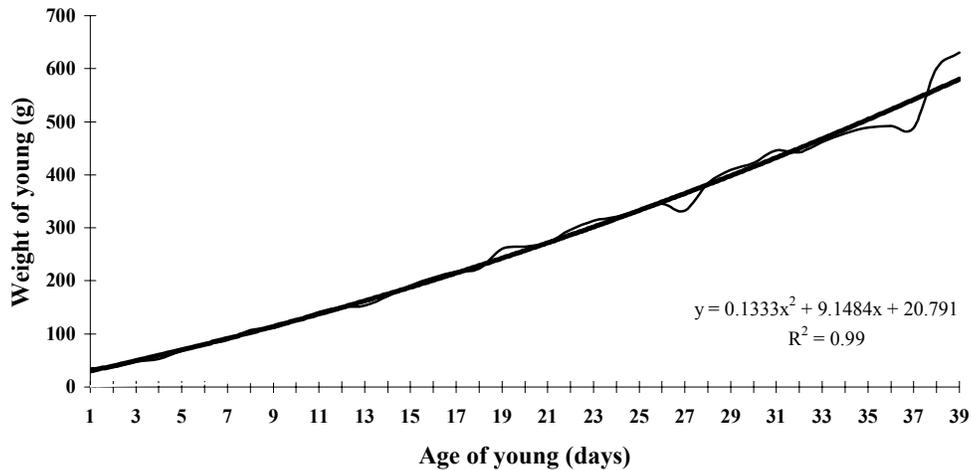
Although bush stone-curlews are born precocial, and therefore basically able to take care of themselves, the young are still fed and protected by their parents until approximately nine weeks of age (Andrews, 1997), at which time they are deemed totally independent (Schodde & Mason, 1980). Despite this independent state, the adult stone-curlews still keep watch over their offspring, and will defend the fledgling if required (Andrews, 1997). Stone-curlews are able to fly by 47 days of age (Schodde & Mason, 1980), and it is generally cited that the young remain with their parents for 47 to 138 days (Pringle, 1987; Marchant & Higgins, 1993). However, delayed dispersal of young has been exhibited by stone-curlews, with young from the first clutch remaining to help defend the eggs and young of the second clutch (Andrews (1997). Some young have been reported to be with their parents beyond nine months of age (Johnson & Baker-Gabb, 1994).

The hatching success of live young from eggs varies greatly in the wild, with a reported 58% success in a Victorian study (Johnson & Baker-Gabb, 1994) and a 90% success in a North Queensland study (Andrews, 1997). Although Schodde & Mason (1980) reported a high infertility rate in bush stone-curlews, the low hatching success in Victoria is most likely due to egg predation by foxes, or by stock-trampling, both events unlikely to occur in captivity. The mortality of young to four weeks of age in the wild appears to be quite high, with only 36-42% of young being raised past this age. However this is similar to that of many other Australian bird species (Ford, 1989). The rearing of two young per clutch is rare in the wild, with only 9-33% of parents being successful (Johnson & Baker-Gabb, 1994; Anderson, 1991). The mortality of young in captivity would be expected to be lower, due in part to the abundance of supplied food, and in part to the lack of threats and predators.

9.10 Young weights and development

At hatching, juvenile stone curlews are covered in a thick pale-grey down with three pairs of dark stripes running along the body. Adult feathers appear on the face and wings at 18 days of age, with predominantly adult plumage covering the body by 25 days. The young are approximately half-adult size at 25-28 days, three quarter adult size at 33 days and fully grown by 50 days. The age-weight chart produced below was produced using ten bush stone-curlew chicks of known age, some of which were raised by their parents in the wild, and some of which had been orphaned and were hand-raised by a wildlife shelter.

Figure 4: Growth curve for juvenile bush stone-curlews – use with caution as these weights are a combination of wild born and hand-reared individuals.



10 ARTIFICIAL INCUBATION AND REARING OF BUSH STONE-CURLEWS

The artificial rearing of the bush stone-curlew as described below is that published for birds in general, and is not specific for stone-curlews. Other shorebird species have been successfully incubated and reared using the procedures described below, and one can only assume at this point that these methods would be as equally successful for the bush stone-curlew.

10.1 Incubator type

There are two types of incubators used in the artificial incubation of bird eggs – the ‘still air incubator’ and the ‘forced draught incubator’ (Finger, 1995). Both of these are suitable for the incubation of a bush stone-curlew egg. The ‘still air incubator’ is a very simple form of incubator, and does not allow more than a single level of egg incubation due to the varying temperature within the incubator body. For this reason, the ‘forced draught incubator’ is the preferred incubator, allowing a greater number of eggs to be incubated at the one time in a stable temperature environment.

10.2 Egg incubation requirements

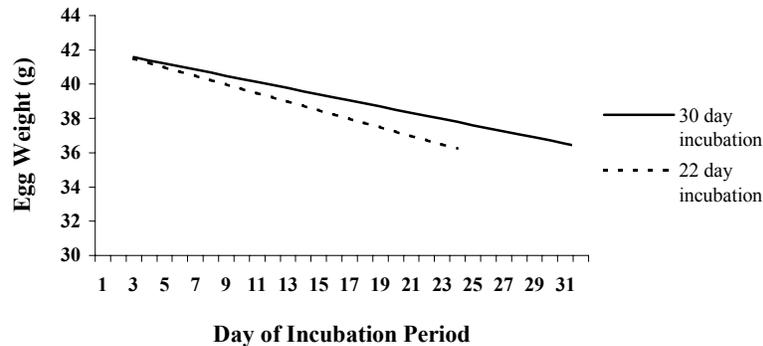
There are four requirements necessary for the successful hatching of any egg – temperature, humidity, turning and ventilation and air flow (Jordan, 1989; Finger, 1995).

Temperature is by far the most important of these variables. Whereas a degree of variation in the other three variables is permissible, resulting in only marginal effects on the hatch success, a slight variation from the ideal in temperature will lead to unsuccessful hatchings. It is the egg centre (embryo) temperature which is important. For hen eggs, which are approximately the same size as bush stone-curlew eggs, this is 37.5°C (99.7°F), slightly cooler for large eggs and slightly warmer for smaller eggs.

Humidity is less critical than temperature as the developing chick has some control of the moisture level by absorbing or releasing some amniotic fluid. Between the time of laying and the time of hatching, the egg should lose 13% of its weight by moisture evaporation. Factors such as the type of egg, the ventilation rate, the handling of the egg, the breeder diet and the

season of laying will affect the rate of weight loss. The best way to monitor the weight loss in the egg throughout the incubation period is to weigh the egg regularly. The average fresh egg weight for a bush stone-curlew is 41.75g.

Figure 5: Sample weight loss expected for bush stone-curlew egg throughout incubation



If the egg is too light, increase the humidity; if the egg is too heavy, then decrease the humidity. For a more detailed explanation on humidity determination, refer to any incubation or artificial breeding publication, such as Jordan (1989) or Finger (1995).

The turning of the egg is vital for the survival of the chick, as it prevents the yolk from touching the shell membrane. Birds with small clutches frequently turn their eggs (D. Carr, *pers. com.*), so turning should be done as often as possible, usually twenty-four times per day. Many incubators will turn the eggs automatically, although some of the simpler incubators may only turn twice a day, or not at all in which case eggs will have to be turned manually.

Most incubators have fixed ventilation and air flow. If these must be altered, it is important to maintain humidity. The amount of oxygen required by developing chicks increases during the incubation period. However if the air flow is too great, the egg will cool and weaken, possibly killing the chick. If the air flow is too slow, the embryo will overheat, again weakening the egg and possibly killing the chick.

10.3 Normal pip to hatch interval

Hatching usually begins three or four days prior to the expected hatch date (Jordan, 1989); in bush stone-curlews this would be at day 18-26. The hatching process starts with drawdown, just prior to when the chick 'internally pips', that is it breaks the air cell to begin the transition from the totally fluid environment to one of breathing air. It is at this stage when the egg is transferred from the incubator to the hatcher. Approximately 24 to 48 hours after the internal pip, the chick will push a small hole in the egg shell using its egg tooth. A newborn chick should be totally emerged within the following 24 to 72 hours (Jordan, 1989).

10.4 Hatcher unit

The hatcher unit should be set at around 36.9°C (98.5°F), or approximately one degree less than the incubator. The humidity in the hatcher must be elevated enough to prevent the chick from drying out during the hatch and sticking the inner membrane of the egg (Jordan, 1989). The egg should be placed on a clean, dry material that is not too harsh for a newborn chick (such as shavings). Newly hatched chicks require only warmth and an absence of draught for the first few hours of their life, so it is best to leave the chick in the hatcher until the down dries and 'fluffs', so as to maximise insolation and therefore maintain body temperature. The

chick may not require food for up to 24 hours, when the yolk in the gut is absorbed. Hydration, however, is very important so ventilation must be increased as soon as the chick has hatched (D. Carr, *pers. com.*).

10.5 Brooder types

There are two basic types of brooder method (Finger, 1995). The first is a completely controlled temperature environment, where the temperature within the brooder is relatively constant and adjusted every few days to allow the chicks to acclimatise to the outside world. Temperatures may start at 38-39°C and reduce to 20°C by the time the young are ready for outside. Of course this may vary depending on the outside temperature. The second type of brooding method is the hot zone/cool zone brooding, where there is a zone in the brooder at a warm temperature (38°C), surrounded by a cool zone (20°C), giving the chicks the choice depending on their needs. It must be remembered that bush stone-curlews are precocial; they are feathered and can regulate their temperature better than an altricial chick, and therefore the second brooder type is recommended.

10.6 Diet

As noted earlier, bush stone-curlews are precocially-born chicks, thereby being able to feed themselves within their first few days of life. By offering the food in a small, shallow bowl (<1cm deep), and tapping at the food item with a pair of tweezers, precocial chicks quickly become proficient at feeding themselves. The first few meals may have to be initiated by force-feeding, but after this, chicks are usually eager to feed.

Food is best fed at room temperature when the chick is young, and increasing or decreasing to ambient air temperature as the chick moves outdoors. When first beginning to feed the chick, feeds should be approximately every two hours throughout the day and evening, but as the chick gets older, these feeds can decrease in number, with the amount of food being offered increased.

Like any growing chick, bush stone-curlews require a variety of food items for high nutritional value. It is best to start with small food items, and increase the food size as the chick ages. It is particularly important with stone-curlews that their calcium intake is sufficient, as a lack of calcium in these earlier stages often leads to leg-bone problems as the stone-curlew reaches sub-adult. Access to natural ultra-violet light (sunlight) is the most preferred and appropriate method to ensure calcium absorption and bone development. If all the required vitamins, minerals, proteins, fats and carbohydrates are not naturally found in the food items offered, supplements may need to be added to the diet. Shorebirds, including bush stone-curlews have been successfully raised on a combination of the following food items: maggots, mealworms, fly pupae, crickets, chopped 'pinky' mice, chopped earthworm and small moths. As they reach a few weeks of age, chicks can be encouraged to eat a 'meat mix' as detailed earlier in this manual. This is particularly important if the bird is to stay in captivity, as it will more easily adapt to the captive diet if started early.

10.7 Specific requirements

Although the bush stone-curlew gives birth to a precocial chick, the security and warmth the adult provides in a parent-reared bird needs to be replicated in a hand-reared bird. If possible, it is best to raise more than one of these chicks at a time, thereby providing the warmth and companionship provided by the conspecific. However, this is not always possible, in which case a small feather-duster has proved successful in providing this warmth and sense of security.

10.8 Identification methods

Young bush stone-curlews can be banded with a coloured plastic band from four-weeks of age. If identification of a number of birds younger than this needs to be attained, physical appearance, including size and colour, can be used to separate individuals. If the young are all deemed too similar in appearance, a small spot of a non-toxic colour spray can be used to temporarily mark individuals. Metal bands can be placed on bush stone-curlews from seven weeks of age.

10.9 Hygiene and special precautions

From the early stages of the egg in the incubator, right through the rearing stages to adulthood, the hygiene and cleanliness of the stone-curlew's environment is of great importance for the health and well-being of the bird.

The environment within an incubator and hatcher is warm and moist, perfect conditions for the growth and transmission of many diseases. The brooder is also warm, and has the added issues of food and faeces to increase the likelihood of disease. For these reasons alone, as well as the low resistance of young chicks, it is vitally important that all surfaces, bowls and instruments be kept hygienically clean at all times. With time, the chick will build up its own antibody/immune system so that it is prepared for moving outside, but even then it is important that all water and food dishes, along with the enclosure, be kept clean. More detailed methods of cleaning methods and agents can be found in most aviculture (e.g. Shephard, 1994) or incubation (e.g. Finger, 1995) publications.

10.10 Behavioural considerations

Bush stone-curlew chicks rarely become human imprinted by the adult stage, even after being hand-raised. While they may associate humans with food as youngsters, they do learn to feed themselves quickly, and probably feel they no longer need to rely on people.

The amount of visual and audio contact the young bird has with people should be kept to a minimal. The use of inanimate objects to feed or handle the bird aids in this disassociation. Any association with people is further minimised by being housed with other birds, particularly stone-curlews, during their life.

10.11 Use of foster species

Bush stone-curlews are known to egg-dump in unrelated nests and adopt unrelated young in the wild (Andrews, 1997). For these reasons, there appears to be no reason why other bush stone-curlews, or other shorebird species could not be used as foster parents for this species. It appears to be possible to place either eggs or young with new parents, although this would need to be monitored for any signs of aggression or rejection on the foster parent's part.

10.12 Weaning

As bush stone-curlews are on an adult diet from a very young age, and as they appear to hold little human association even after being hand-raised, they wean very well with little effort. The most important factors for weaning bush stone-curlews is to ensure they are prepared for the climatic change of being moved to an outside enclosure, and that they are totally capable of feeding themselves (which they certainly should be by this age). It is important to watch for signs of aggression in their new enclosure from other birds.

10.13 Rehabilitation procedures

The rehabilitation process for any bird often depends on what is wrong with the bird in the first place. However, some procedures are uniform across all rehabilitation cases, and that is one of warmth and quiet. More often than not, birds requiring rehabilitation are from the wild, and therefore become stressed by any human contact.

If the bird appears to be simply dazed, a few quiet hours in a dark place will bring the bird back to health and it can be released. However, for all other complaints, or if the bird does not recover in the short term, it is important to seek veterinary advice. The rehabilitation procedures from here on will be case specific. While a wild bush stone-curlew will adjust to most holding enclosures without a problem, they can be difficult to feed. Most wild bush stone-curlews will have to be force-fed. This is best achieved by wrapping the bird's body in a towel with its head free, and placing the food item at the back of the throat. From here, the stone-curlew will swallow with no problem.

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