Husbandry Guidelines for the Grey-Headed Flying Fox

Pteropus poliocephalus

Mammalia: Pteropodidae

Date	By	From	Version
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WHS Introduction

Hazards are anything with the potential to cause harm (Work Safe Victoria 2017). In every workplace, various hazards exist. These hazards fall into six main categories. They are biological, chemical, environmental, ergonomic, physical, and psychological. Many hazards faced in animal keeping are not restricted to this the trade. Exposure to the elements and the operation tools or machinery, pose risks that are faced across many a workplace. However, animal husbandry does present a range of hazards that are unique to captive animal care (HSE, 2012). This includes risks associated with food preparation and enclosure design, which feature across almost every species. As well as hazards such as animal handling, that are specific to working with particular species or even certain individuals. Regardless of their nature, all encountered hazards should be eliminated or reduced wherever possible.

It is imperative that staff members, contractors and visitors, comply with all relevant industry standards, legislation, codes of practice, policies and procedures, including those specific to the workplace as these act to protect all people, animals, and the environment.

It is the responsibility of all staff to maintain a safe workplace. This includes:

- Maintaining a clean and tidy working environment
- Complying with rules, standards and safety signage
- Reporting accidents, incidents and hazards
- Participating in tasks that improve or assess safety (Workplace OHS, 2016)

For the captive care of Grey-headed Flying-foxes, it is vital that staff are all aware of the biological, chemical, environmental, ergonomic, physical, and psychological risks that may be faced. This includes hazards synonymous with the species, and those that are general across all areas of animal husbandry. This will help staff to identify and report risks, and can encourage them to act to eliminate or reduce risks where possible.

The Grey-headed Flying-fox is generally not aggressive, however care should be taken when working with any bat species. These relatively small mammals possess sharp teeth and a strong jaw, along with sharp nails and formidable strength. A bite or scratch from a Grey-headed Flying-fox can injure, but more importantly it acts as a pathway to spread disease. There is a risk of injury, illness and even death (through disease), from working with these animals. The safety of staff should therefore be taken very seriously.

All staff should have a sound knowledge of the risks involved in captive Grey-headed Flying-fox care. Enclosures should have clear signs that outline, to both staff and the public, the risks associated with handling or coming into contact with the species. It is vital that all keepers fully understand the risks involved, so that appropriate safety measures can be implemented (Workplace OHS, 2016). This includes the implementation of protocols or standard operating procedures, and the use of personal protective equipment (PPE).

HM Species Risk Category

The Grey-headed Flying-fox is not easily categorised when it comes to risk. While they are not capable of fatally injuring a person, they do have the potential to transmit diseases such as Australian Bat Lyssavirus (ABLV). Surveys of wild bat populations indicate that less than one percent of all bats carry ABLV and since its discovery, there has only been three confirmed cases of the bat borne infection in humans. Sadly however, the disease has proved to be fatal in all cases. Grey-headed Flying-foxes are known to carry other zoonotic diseases, but none others are fatal in humans. Transmission of ABLV in captive environments is preventable and therefore the risk associated is substantially reduced. The implementation of strict safety measures and the availability of an effective rabies vaccine, means that the Grey-headed Flying-fox can now be considered a relatively low risk species.

Workplace Risk Types

Biological

The greatest risks posed by the Grey-headed Flying-fox are biological. Zoonotic diseases are those which can be transferred from animals to humans (HSE, 2012). Some zoonotic diseases are extremely serious and have the potential to be life-threatening. Others cause only temporary, mild illness. Keepers should become familiar with the signs of infectious disease. However, it is important to note that infected animals do not always show signs and may not appear sick. For this reason, it is vital that hygiene protocols are in place to restrict the spread of disease and prevent outbreaks (Wade, 2013).

Biological risks can be reduced by ensuring that display enclosures have a glass viewing area or a stand-off barrier and double wiring (10cm apart) to prevent the public contact with bats (Roth, 2015). Clear signage should also be displayed to warn of the risk of lyssavirus. Grey-headed Flying-foxes should never be housed in walk-through enclosures. When handled by keepers for educational displays, the public should be kept behind a barrier or seated an appropriate distance away (Roth, 2015).

All staff working with or around captive Grey-headed Flying-foxes should be vaccinated. This includes keeping, education, horticultural and maintenance staff. Vaccinated staff should have a rabies antibody titre test every two years as a booster may be necessary to ensure continued resistance. If any person is bitten or scratched, it is advised to thoroughly wash all wounds with soap and water for five minutes, before seeking immediate medical advice (Roth, 2015).

Image 1: Flying-fox enclosure with glass viewing area (Devilfish, 2013)

Image 2: Flying-fox enclosure with double wiring and stand-off barrier. (Geomorph, 2010)

Chemical

Chemical risks are largely a byproduct of cleaning regimes. This includes the use of cleaning chemicals such as bleach, F10 and hospital grade disinfectant. It can also relate to chemicals present in medical treatments such as betadine and iodine, and products used on enclosure maintenance equipment, for example WD40.

Chemical risks can be reduced through the use of appropriate personal protective equipment (PPE) including gloves, face masks and protective eye glasses. It is also important to read all product instructions to ensure the correct dilution, use or administration of chemical products (Wade, 2013).

Environmental

Environmental risks are associated with enclosures, the surrounding area and any other work space needed for captive grey-headed flying-fox care. With most flying-foxes being housed outside in aviary style enclosures, keepers will be required to work outside. This may mean working in extreme temperatures, facing sun exposure, uneven surfaces, loud noises, falling objects (enclosure furniture) etc. These risks can be reduced by ensuring that enclosure surfaces and surrounding walkways are level and free from tripping hazards. Ensuring that enclosures are adequately ventilated. As well as safely securing any hanging items in the enclosure. It is also important to wear appropriate PPE such as, long sleeves, hat and sunglasses in warm weather, and protective glasses, gloves and/or earmuffs when operating certain equipment.

Ergonomic

Grey-headed Flying-foxes live in an upside-down world, so their enclosures can pose an ergonomic challenge for keepers. Common problems include poor layout or difficult access. Associated hazards include straining to reach items or animals overhead and extended periods spent in awkward positions (e.g. looking up). This can be reduced through sound enclosure design or aftermarket modifications (HSE, 2012). Enclosures should have easy access and an appropriate height, so that keepers are not required to duck under doors or over extend when reaching up to retrieve enclosure furniture or animals.

Other ergonomic challenges relate to the setup of food preparation areas. Grey-headed flying-foxes consume large quantities of fruit each day, and for a large colony this can take a long time to prepare. Extended periods spent at poorly laid out work station can lead to back and neck injuries. Risks can be reduced by modifying areas and using height adjustable benches.

Physical

The main physical risks in captive grey-headed flying-fox care relate to capture and manual handling. It is during these potentially stressful situations that animals are most likely to lash out. Flying-foxes have sharp teeth and claws, which they may use when frightened or in pain. This can result in bite wounds or lacerations to their keepers or handlers (Wade, 2013)

When working with the Grey-headed Flying-fox, keepers should consider the behavioural traits of the individual as well as that of the species. Bats that are regularly handled from a young age may tolerate being held. Conditioning and desensitisation can play an important role in minimising the physical hazards associated with handling. However, this type of preventative measure is not always possible and does not guarantee safety. It is therefore important to wear appropriate protective clothing when capturing, moving, assessing, or administering first aid (Wade, 2013). It is recommended to wear gloves and sleeve protectors, in addition to using the correct handling techniques.

If bitten or scratched, immediately wash the wound with soap under running water for at least 5 minutes. As a precaution, professional medical attention should also be sought, even for vaccinated handlers.

Psychological

Psychological risks primarily relate to the mental challenges faced in captive Grey-headed Flying-fox husbandry. Anyone that works with these animals will know that their intelligence is comparable to that of a young child. They are extremely social animals, who enjoy human interaction (Wade, 2013). Keepers can therefore form strong attachments, particularly to animals that have been raised in their care. The loss of such individuals can lead to feelings of sadness, anxiety or depression.

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1 Introduction

This manual, *Husbandry Guidelines for the Grey-headed Flying Fox*, aims to assist anyone who is/or hopes to work with captive grey-headed flying foxes in the future. It draws on the latest industry standards, government requirements, best practices and recommendations. And is designed to provide up-to-date information on all areas of grey-headed flying fox care, including housing, feeding, transporting, handling, breeding and rearing of young.

Captive grey-headed flying foxes play an important role in educating the public on their important place in our ecosystem. Far from a vampire or rabid monster, they grey-headed flying fox is almost like a puppy dog with wings. When people do see these beautiful and inquisitive creatures up close, they are often filled with fascination and empathy.

The grey-headed flying fox is a keystone species with the vital ecological role of pollination and seed dispersal. But sadly, they are maligned by many people. Although they appear to be abundant in many areas, the reality is that this native Australian species – like so many others – is in danger of going extinct. Habitat destruction has forced flying foxes to migrate to urban environments in order to survive. But living close to humans has exposed them to more threats, including electrocution, entanglement and even shooting.

Many animals, including humans, rely on trees – to provide food to eat, materials to make a home and oxygen to breathe. The Australian Koala Foundation coined the phrase “No Tree, No Me” as part of conservation efforts for this more popular species. But what people often forget, is that the opposite rings true for the humble grey-headed flying fox – “No Me, No Tree”. They truly are a species that we cannot live without.

Taxonomy

1.1 Nomenclature

Class: Mammalia
Order: Chiroptera
Family: Pteropodidae
Genus: *Pteropus*
Species: *poliocephalus*

All bats belong to the order *Chiroptera*, meaning 'hand-winged'. Grey-headed Flying-foxes belong to the mega-bat suborder Megachiropta, commonly known as fruit bats, old world fruit bats or flying foxes (Jackson, 2007). Bats of the genus *Pteropus* are the largest in the world. The name *Pteropus* is believed to be derived from a Hellenistic Greek word meaning 'wing-footed', while *poliocephalus* translates to 'grey-headed'.

Figure 2.1: The distinctive grey head is how the species got its name (NSW Gov 2017).

1.2 Subspecies

There are no recognized subspecies.

1.3 Recent Synonyms

No synonyms have been associated with this taxon yet.

1.4 Other Common Names

The Grey-headed Flying-fox is sometimes spelt Gray-headed Flying-fox or Grey Headed Flying Fox. They are also sometimes referred to as just Flying-fox or Fruit bat (Hall & Richards, 2000).

2 Natural History

The Grey-headed Flying-fox is one of approximately 925 different species of bats, the only mammals capable of sustained, active flight. Due to their nocturnal lifestyle, flying capabilities and other ecological adaptations, bats have become an extremely successful group. They are the second most diverse group, making up 20% of all living mammal species, and the second most numerous (Hall & Richards 2000).

Bats first appeared in the fossil record 58 million years ago. This appearance was sudden, and it is believed that strong selective pressures were responsible for the quick transition. There are few fossils showing the development of wings, which may be explained by the bats delicate bones (Hall & Richards 2000).

Bats have semi-transparent wings, made up of two layers of skin stretched between their forelimb bones (Hall & Richards 2000). Their other features however, are not unlike those seen in other mammals. This has led to suggestions that they may be related to mammals include flying lemurs, tree-shrews, and even primates with whom they share similar brains and soft tissue.

Bats are broadly divided into two sub-orders known as ‘micro’ and ‘mega’-chiroptera. Microchiroptera are generally smaller, feed largely on insects and navigate using echolocation. Megachiroptera are larger bats that navigate primarily by sight. The sub-order Megachiroptera contains only one family, Pteropodidae, containing five genera of 13 species. These are the flying foxes, fruit bats and blossom bats, including the Grey-headed Flying-fox.

Ecologically, bats are seen as vital ‘keystone species’ for their role in fruit pollination, seed dispersal and insect population control. They are critical for the maintenance of healthy, functioning ecosystems. Despite their environmental importance and numerous numbers, they continue to be underrepresented in zoological institutions.

2.1 Morphometrics

2.1.1 Mass And Basic Body Measurements

The Grey-headed Flying-fox is one of the largest bats in the world, weighing between 300-1100g with a wingspan of over 1m. They have a head-body length of 230-289mm (Eby & Lunney 2002) and a forearm measurement of 138-180mm (Parish, Richards & Hall, 2012).

Figure 3.2: A photo showing the wingspan of an adult Grey-headed Flying-fox (Flickr, 2017).

2.1.2 Sexual Dimorphism

Among mammals it is common for males to mature later and reach a larger size than their female counterparts. This trend is reversed for many bat species, but not for members of the *Pteropus* genus, including the Grey-headed Flying-fox. Welbergen (2010) observed sexual size dimorphism and bi-maturation among adults. While the length and mass of juveniles increased independent of sex, adult males averaged 1.8 to 4.5% larger for skeletal measurements. They were also 25% heavier, and this increased to 40% at the start of the breeding season. Size dimorphism is likely a result of prolonged male growth and delayed maturation, with males maturing at a larger skeletal size. It is believed to be related to intrasexual selection for fighting ability among males, along with the size constraints on females for carrying heavy young (Welbergen 2010).

2.1.3 Distinguishing Features

As the name suggests, the Grey-headed Flying-fox has a silvery-grey head of fur. It is distinguishable in Australia as the only species of bat with a collar of orange-gold fur that fully encircles the head (Hall & Richards 2000). The Grey-headed Flying-fox can be distinguished from similar species in the *Pteropus* genus, as it is the only one with fur that grows all the way down to the ankle (Parish, Richards & Hall, 2012). They Grey-headed Flying-fox has grey belly fur, sometimes with white or ginger flecks, and dark grey to silver back fur. Fur is darker in winter before molting for the warmer summer months (Department of the Environment, 2017).

2.2 Distribution and Habitat

The Grey-headed Flying-fox is endemic to Australia and found in the eastern regions of Victoria, New South Wales and southern Queensland.

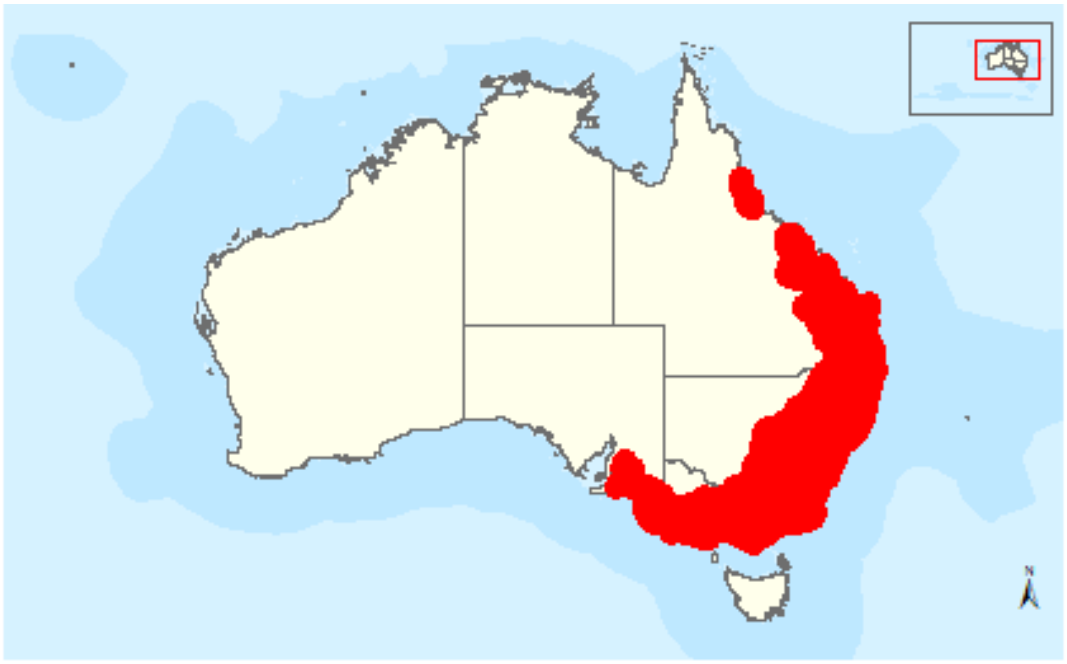


Figure 3.3: Distribution of the Grey-headed Flying-fox (Department of Environment, 2017)

As a highly mobile animal, the national population of Grey-headed Flying-fox is always moving. Grey-headed Flying-foxes commute daily to forage for food. While they usually only move within 15km of the roosting site, they are capable of flying over 100km in a single night (Tidemann, 1998). A tracking study by Tidemann & Nelson (2004) found that individuals made round trips of more than 2000km over a nine-month period. Bats also migrate over periods of time, moving up and down the east coast in pursuit of food and nesting habitat. Previous studies also indicate that bats move seasonally in response to changing food availability, regularly migrating between camps (Eby, 2000).

They inhabit urban areas, rainforests, woodlands, swamps, and intertidal mangroves (Department of Environment, 2017). They roost within the vegetation, on various sized, exposed branches. Roost sites are typically located near water bodies such as rivers and lakes. Bats are also attracted to commercial fruit crops, orchards and urban areas that contain introduced tree species.

2.3 Conservation Status

The Grey-headed Flying-fox is listed as Vulnerable on the IUCN Red List (Lunney, Richards & Dickman 2008). The change in conservation status occurred in 2008 due to a population decline of approximately 30% over three generation. This was attributed to loss of habitat, competition, and hybridization with *P. Alecto* (Eby & Lunney 2002).
The Grey-headed Flying-fox has a national status of Vulnerable under the EPBC Act. However, protection varies among states, with the Grey-headed Flying-fox being listed as 'Threatened' in both Victoria and New South Wales but 'Least Concern' in Queensland (Nature Conservation Act 1992).

2.4 Longevity

2.4.1 In the Wild

The life expectancy of wild Grey-headed Flying-foxes has not been well studied but is estimated to be between 10-25 years. A study of 86 wild banded bats found that the average lifespan to be 7.1±3.9 years, with the oldest wild bat to be recaptured being 18 years old (Tidemann and Nelson 2011).

2.4.2 In Captivity

Megachiropterans do well in captivity, and generally live as long, if not longer, than their wild counterparts. Captive Grey-headed Flying-foxes have an average lifespan is 23.6 years (Weigl, 2005).

2.4.3 Techniques Used to Determine Age in Adults

There are three recognized life stages of the Grey-headed Flying-fox:

1. Juvenile – not fully weaned, usually less than 40 days old
2. Subadult – from juvenile to adult
3. Adult – fully grown and sexually mature

Determining an exact is difficult unless the date of birth is known. Several techniques have been used to determine the age of bats, to varying degrees of success. The figure below outlines techniques which can be used to determine the life stage of an individual.

Character	Juvenile	Sub-adult	Adult
Size (weight and forearm length)	<80% adult	80-100% adult	Adult
Teeth	Milk teeth may still be present, others needle sharp	Sharp and unworn	Showing wear
Teats (female only)	Almost invisible	Almost invisible	Clearly seen
Finger joints	Unfused; large and obvious cartilaginous bands.	Not fully fused; cartilaginous band and blood vessel distinct.	Fully fused, knobby; cartilaginous gap not visible.

Figure 3.4: General characteristics of different life stages in bats (Reardon & Flavel 1987 and Parnaby 1992 **in** Jackson 2007).

To determine the age of adults, requires close examination of growth layers in the bone, and cementum and dentine in the teeth (Divljan, Parry-Jones & Wardle 2006). This can only be performed on deceased animals. However, it is possible to assess the teeth of live animals for signs of wear indicative of age. This ranges from unworn pointed teeth on young adults, to fully worn teeth (at times to the gum) on older individuals (Jackson, 2007). This technique for aging is best used by people who are familiar with variation between ages and individuals.

3 Housing Requirements

3.1 Exhibit/Enclosure Design

Exhibit design is an important part of maintaining grey-headed flying-foxes in a captivity. Exhibits should be designed with both the occupant/s' biology and husbandry requirements in mind. In other words, a hygienic environment, with adequate space and provisions to meet the physical and psychological needs for all occupants. Exhibits must meet all relevant legislation and follow codes of practice and guidelines for the species. These often relate to size, design, furnishings, hygiene, welfare and WHS.

Enclosure size requirements for the grey-headed flying-fox are outlined in the Exhibited Animals Protection Act. As an active species that uses both climbing and flying for locomotion, flying-foxes require a significant amount of space and adequate structures on which to climb. Specifics are outlined in the sections below.

Despite being nocturnal, grey-headed flying-foxes tend to do better in outdoor exhibits, opposed to nocturnal houses (Jackson, 2007). This is because flying-foxes are still active during the day and sun basking is an important behaviour for this species. Access to sunning areas help to maintain healthy wing membranes and vitamin D intake.

3.2 Holding Area Design

Holding areas can be used for short-term maintenance, to quarantine new animals, to separate individuals receiving medical/veterinary treatment, or to transition hand-reared young into exhibits. Therefore, the same basic principles used in exhibit design should be followed in the design of holding areas. This means holding areas must provide adequate climbing opportunities, access to natural light cycles and have easily accessible food and water station(s). Enclosure walls, furniture and substrate, should be non-abrasive to prevent injury, as well as being well sealed to withstand regular cleaning. Newspaper is popularly used as substrate in holding areas, as it is easy to replace for cleaning purposes (Jackson, 2007).

Bats that are restricted from flying for over a month may lose muscle condition, resulting in a loss of flight (Jackson, 2007). Unless advised by a veterinarian, flying-foxes should be housed in enclosures that allow for short flights. Holding areas that facilitate flight should be at least four times the wingspan wide and four times the length of the body high (Jackson, 2007), or wider for sustained flight. Non-flight holding areas can be as small as one and a half times the wingspan of the occupant (Jackson, 2007).

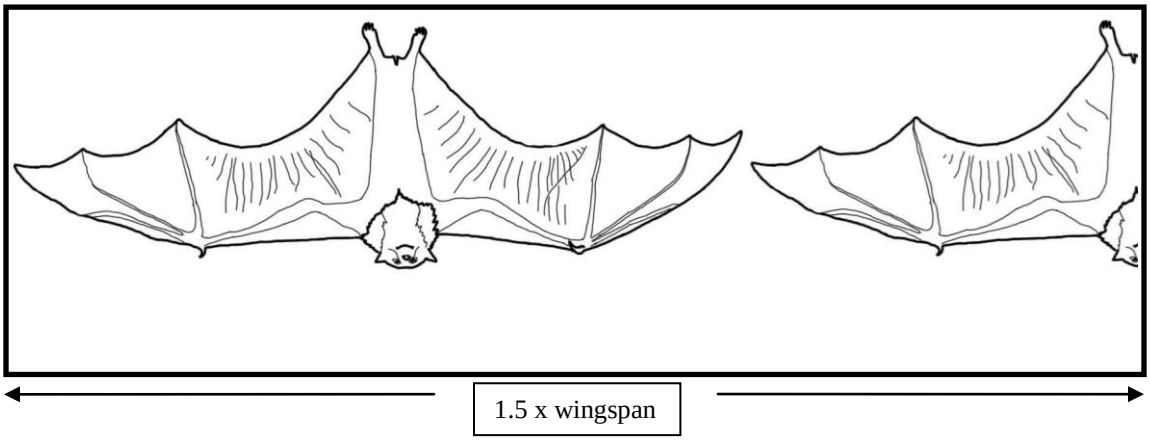


Figure 4.2.1: Non-flight holding areas should be 1.5 x the wingspan, and a comfortable height so that the occupants head does not reach the ground (Jackson, 2007).

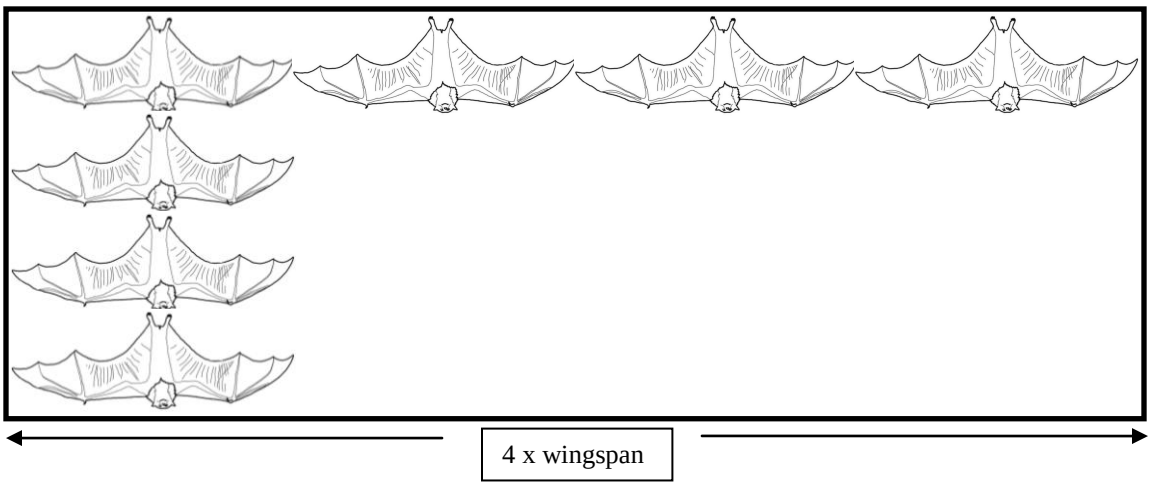


Figure 4.2.2: Flight-facilitated holding areas should be 4 x the wingspan, and 4 x the height of the occupant.

3.3 Spatial Requirements

Grey-headed flying-foxes should not be held as solitary due to their highly social nature (DPI, 2006). For this reason, enclosures must be large enough to adequately meet the needs of all occupants. Flying-foxes should be provided with enough room outstretch both wings and to make short flights (DPI, 2006). The minimum housing size varies from state to state. The spatial requirements for flying-fox exhibits in New South Wales are included in the table below.

Head-Body Length (cm)[1]	Minimum Enclosure Area (m^2)	Minimum Enclosure Height (cm)	Addition floor area for each extra animal
29	15.00	300	1.50 x 1.50

Table 4.3: Spatial housing requirements for flying-fox species, as stated by the Exhibited Animals Protection Act 1986.

3.4 Position of Enclosures

Despite being 'nocturnal' grey-headed flying-foxes are extremely active during the day, and they have excellent vision. Enclosures should therefore be positioned in such a way that occupants have access to natural light. This will also afford them the necessary opportunities for basking in the sun.

3.5 Weather Protection

Protection from the elements is vital for any species. Housing should allow individuals to seek shelter from wind, rain and direct sunlight (Jackson, 2007). At Animals of Oz, this is achieved by enclosing one end of the enclosure using a roof, and solid walls on three sides. Grey-headed flying-foxes are also susceptible to overheating so adequate shade must be provided. This allows animals to escape from the heat and protects against UV radiation. This can be achieved using a shade cloth or vegetation (DPI, 2006).

3.6 Temperature Requirements

Grey-headed flying-foxes should be kept at temperatures similar to what they experience in the wild. As the grey-headed flying-fox is widespread in Australia, inhabiting a range of climates, artificial heating or cooling may not be necessary. Focus should instead be placed on allowing animals to thermoregulate effectively (Jackson, 2007). This means providing access to sunlight for basking, shady areas in which to cool off, and blankets to snuggle in during cold weather.

3.7 Substrate

Substrates for the grey-headed flying-fox should be non-abrasive, have good drainage qualities and be easy to clean (DPI, 2006). Smooth concrete is often recommended, at least in feeding areas, as it can be hosed down (Jackson, 2007). However, it does not have an appealing aesthetic. Other possible substrates include soil, grass, mulch and sand. If using any of these substrates, it is important to monitor that flying-foxes are not scavenging for food off the ground, as the substrate may be harmful if ingested. At Animals of Oz, we use sand as substrate in the feeing area and have mulch in the rest of the enclosure. The sand allows for ease of raking, necessary for the removal of food waste and excrement that builds up in the area.

3.8 Nestboxes and/or Bedding Material

The grey-headed flying-fox is a tree roosting species. As they usually roost on the exposed branches of tree canopies, nest boxes are not necessary. Bedding material however, can be provided in the form of hanging towels or fleece blankets. These provide warmth, comfort and a place for flying-foxes to hide and seek shelter from the elements.

3.9 Enclosure Furnishings

Enclosures must provide adequate climbing opportunities for all occupants (DPI, 2006). This includes the wire cage itself, but can also incorporate ropes, ladders, blankets or towels, and natural or artificial branches or vines. At least some of these items should extend to the ground, so that fallen animals have the opportunity to climb back up (DPI, 2006). They should also be hung in such a fashion that the flying-foxes have room to fly (Jackson, 2007). It is important to ensure that all enclosure walls and furnishings are free from sharp edges, as these have the potential to cause wing tears.

Enclosure furniture can also include native plants. Flowering species such as bottlebrush, or fruiting trees such as native fig, provide shelter, novel textures and help to stimulate natural foraging activity. In addition, shallow pools can be added to flying-fox enclosures to provide a water source and way to cool off in the summer heat.

Multiple feed stations should be spread throughout the enclosure, to reduce aggressive altercations over food (DPI, 2006). Dip water bottles are commonly used to provide water, and feed stations can comprise of hanging food bowls, buckets, skewers or other novel feeding apparatus.

3.10 Sustainability

Positioning enclosures effectively can help to provide passive heating and cooling, so that artificial heating and cooling methods – such as heat lamps and fans/sprays – rarely need to be used.

If heat lamps are being used at night for warmth, these can be set on a timer / switched off during the day to save on power. If fans / sprinklers are being used to cool the exhibit during warm weather, these should also be set on a timer or closely monitored to avoid water wastage and excessive power consumption.

Branches used to furnish grey-headed flying-fox enclosures can be recycled within other exhibits. For example, when branches in the grey-headed flying-fox enclosure dry out and need to be replaced, these can be given to other species for enrichment. Due to their strong odor, grey-headed flying-fox leaf is perfect for scent-driven species.

4 General Husbandry

4.1 Hygiene and Cleaning

Grey-headed flying-foxes produce a large amount of waste so regular enclosure cleaning is essential. Cleaning enclosures to maintaining good hygiene is essential to reduce odours caused by excrement and discarded food. It also helps to prevent insect or vermin infestation. It is important that all uneaten food is removed from the enclosure the following morning. Food containers should be washed or replaced daily, and water bottles should be cleaned regularly. The enclosure substrate should be well draining and easy to clean, as this should be done daily. This involves hosing down concrete areas and raking sand or soil. Depending on the enclosure size and number of occupants, lose substrates will also need to be added to or replaced.

Enclosure furniture should be replaced as necessary, and otherwise maintained in a clean and hygienic condition, free from the accumulation of faeces or waste. This involves removing, washing and replacing toys and soiled blankets. When scrubbing enclosure walls or furnishings, it may be appropriate to use a chemical agent such as f10 or other veterinary approved disinfectants. Surfaces should be rinsed after disinfecting, and before animals come into contact with the area. Any water bodies in the enclosure will require regular cleaning or good filtration, so that food waste, feaces and debris can be removed.

4.1.1 Annual cycle of Activity

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
MATING SEASON												
BIRTHING SEASON												
ENCLOSURE REPAIR/RENO												
ENCLOSURE FULL CLEAN												
HEALTH CHECKS												
ANNUAL VET VISIT												

- Mating occurs between April and May. As the gestation period of the grey-headed flying-fox is 6 months, offspring are usually born in mid to late spring.

- To cause minimum disturbance, enclosure repairs and renovations should be done in July or August, as this is after the mating season has occurred, but before offspring arrive. A full enclosure clean can also be done at this time.

- Routine health checks should be performed monthly.

- Annual vet checks can be scheduled for March in preparation for the start of the breeding season, and when young have had time to become more independent and semi-weaned.

4.2 Record Keeping

Regular and accurate record keeping is recommended for the care of captive Grey-headed Flying-foxes. Records serve as a database which can be vital for recalling or passing on information, as well as for identifying trends. Information that may be recorded includes:

- Births, deaths and transfers
- Weight and body measurements
- Behavioural changes
- Courting or mating
- Dietary adjustments
- Results of health checks
- Veterinary procedures
- Administration of medications
- Other medical treatments

The above examples can be recorded in a number of ways, including identification cards for individual animals or dedicated tables based on record types (e.g. weights). Records should be maintained regularly and accurately and passed on if an animal is transferred to another institution.

4.3 Methods of Identification

A variety of identification techniques have been used on Grey-headed Flying-foxes over the years, to varying degrees of success. Below are methods that could be implemented for individuals in captivity:

- Visual identification – physical variation among bats in small colonies can be used for identification purposes. Differences can include size, colouration and scars on both the body and wing membrane. These variations can be recorded in the form of photographs or written descriptions and should be updated as the animal ages.

- Nail polish – a simple and less-permanent identification method is nail polish, which can remain visible for up to a month. Coloured polish can be applied to toe nails or thumb claws, with the colour(s) and location acting as an identifying marker.

- Banding – commonly used to identify wild bats, bands can be used on the thumb of the Grey-headed Flying-fox. Metal bands are recommended over plastic bands, as they are more resistant to chewing. Bands should be fitted correctly and never used on animals that are still growing.

- Necklaces – there are several types of necklace that have been used previously on captive bats including ratchet-style plastic ties or self-locking cable ties. The necklace should be small enough to prevent removal without causing physical discomfort, and again, they should not be used on bats that are still growing.

- Microchip – a non-visual means of identification, microchips can be scanned for identification purposes. Microchips should only be implanted by an experienced keeper or veterinarian, and should be placed between the left scapulae and spine. While microchipping is the most expensive option, it is also the longest lasting.

4.4 Routine Data Collection

Routine data collection includes records that may be required as part of a long-term study. These records can be used to better understand the species. Data that could be routinely collected and assessed includes:

- Births and deaths
- Weight and body metrics
- Behaviours

The collection of data on behavioural patterns and physical characteristics can greatly contribute to the husbandry of the species. It can be used to gain a better understanding of captive life expectancies, behaviours, sociality among groups, rearing of young and more.

5 Feeding Requirements

5.1 Diet in the Wild

The grey-headed flying-fox has an important ecological role, dispersing seeds and pollen of native plants (Hall & Richards, 2000). They have therefore evolved in parallel with the flowering and fruit bearing trees from which they feed. They have sharp teeth to break through fruit skins, and back molars used for crushing fruit (Parish, Richards & Hall, 2012). The juice and pulp of the fruit is consumed, and the roughage is spat out. Therefore, they only need to process high energy liquids and pollen. For this reason, the grey-headed flying-fox has a very short intestine, with a rapid rate of passage – as quick as 15 minutes (Parish, Richards & Hall, 2012).

In the wild, the grey-headed flying-fox consumes a diverse native diet that is supplemented with introduced plant species. They are considered dietary generalists, as they will consume almost species that is available to them (Hall & Richards, 2000). They eat a variety of native species including the nectar and pollen eucalypts, melaleucas and banksias, as well as native fruits such as figs (Department of the Environment, 2017). They also enjoy introduced plants, and unfortunately, will sometimes take fondly to flowers and fruits grown in orchards and ornamental gardens. The grey-headed flying-fox has no adaptations to cope with food shortages, and they therefore migrate and alter their diet in response to the availability of food (Department of the Environment, 2017).

5.2 Captive Diet

An adult grey-headed flying-fox will consume between 25 and 35% of their body weight in fruit each day (Jackson, 2007). Therefore, the average sized adult will eat around 350gms of chopped fruit (plus supplements) daily. Around two thirds of the diet should be hard fruit, with the remaining one third able to comprise of soft fruits. It is recommended that this ratio be achieved with a minimum of three types of fruit being offered (Jackson, 2007).

Suitable hard fruits include apple and pear. Soft fruits include fig, mango, kiwi fruit, seedless grapes, berries, stone fruit, lychees, pawpaw, cantaloupe and other melons (Jackson, 2007; South Australian Government, n.d., Wade, 2013). Banana can also be provided, but only in small quantities, as it is high in fibre and can therefore cause problems with digestion (South Australian Government, n.d.). Some flying-foxes will also enjoy citrus, such as mandarins and oranges, which can be offered sparingly, along with sweet vegetables such as canned corn.

The captive diet for the grey-headed flying-fox will vary greatly throughout the year, due to seasonality and availability of fruits. Caution should be taken in selecting fruits for flying-foxes that will eventually be released into the wild, because feeding certain fruits can encourage them to raid orchards, a dangerous pastime for a flying-fox (Wade, 2013).

Juvenile flying-foxes are not fully weaned until five or six months of age. However, they are capable of foraging for food from around four months (South Australian Government, n.d.). In captivity, dependent young will begin by licking juice from their mother at six weeks. At eight weeks, they may start to consume small pieces of fruit given to them by their mother. By twelve weeks they should be capable of eating adult size pieces of fruit (South Australian Government, n.d.). Extra care should be taken when distributing a diet that will be consumed by juveniles, as excessive fiber can cause bowel issues. Juveniles that are separated from their mother should not be given fruit until they are able to successfully extract juice and spit out the fiber (South Australian Government, n.d.).

The grey-headed flying-fox diet can be prepared in a number of ways. At Animals of Oz, we dice the fruit into bite size pieces 2cm cubes. Other ways to prepare food include hanging whole foods or sliced items such as cantaloupe (Jackson, 2007).

As mentioned in section 6.1, the favored diet of the grey-headed flying-fox includes the nectar and pollen of native species. Therefore, eucalypt, banksia and melaleuca can be provided as blossoming browse or planted species within the enclosure.

Example weekly diet

	Diet
Monday	60% Apple, 20% cantaloupe, 20% grape
Tuesday	60% Apple, 20% cantaloupe, 20% mango
Wednesday	60% Apple, 20% cantaloupe, 20% grapes
Thursday	60% Apple, 20% cantaloupe, 20% mango
Friday	70% Apple, 10% banana, 20% grapes
Saturday	70% Apple, 10% figs, 20% mango
Sunday	70% Apple, 10% figs, 20% grapes

5.3 Supplements

A high protein supplement should be added to boost the protein content of the grey-headed flying-fox diet. Wombaroo high protein supplement is popularly used, and is given at a dose of 10g (2 heaped teaspoons) of supplement over 300g of fresh apple per adult. This should be increased to 20g (4 heaped teaspoons) for individuals pregnant, nursing, juveniles or those that are unwell.

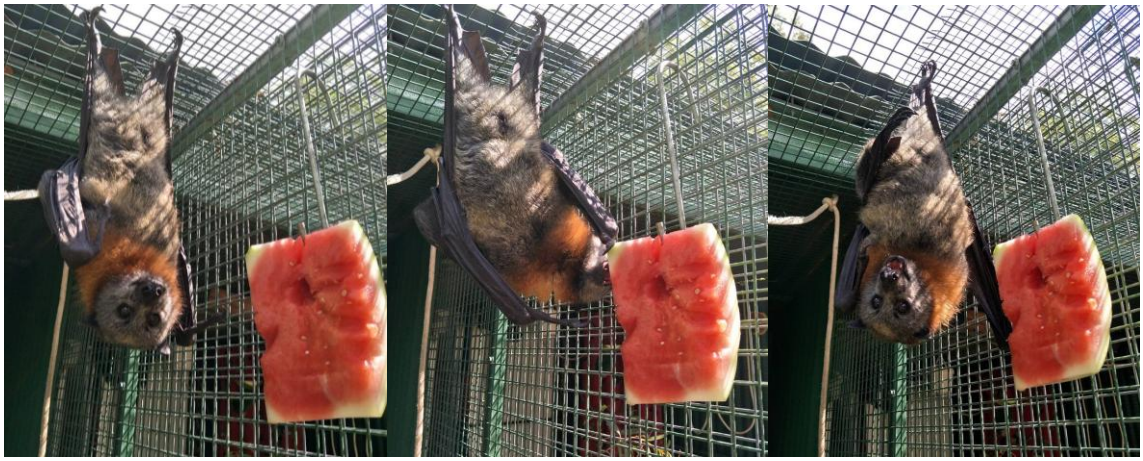
A salt-block or mineral lick should also be provided. Additional supplements that can be added to the diet occasionally include glucosamine, vitamin C powder, calcium syrup and blossom nectar (South Australian Government, n.d.).

5.4 Presentation of Food

Grey-headed flying-fox enclosures must have multiple feed stations, preferably one per animal. These should be spread throughout the enclosure to reduce aggressive altercations over food (Department of Primary Industries, 2006). All food and water stations should be easily accessible by both animals and staff.

Food can be presented in a number of ways, and this provides one of the simplest forms of behavioural enrichment. The presentation of food can be altered by peeling or not peeling certain foods, cutting the foods into novel shapes, or by offering whole food items. Fruits can be also be processed into juices, frozen in ice-blocks or mixed with gelatine to make fruit jellies (South Australian Government, n.d.).

The grey-headed flying-fox diet can be presented in bowls or hanging buckets that are easily accessible. Other novel ways to present food include: creating fruit skewers/kebabs by threading fruit onto stainless steal rods; placing soft fruit within a suspended cage; or hanging fruit pieces from enclosure furniture such as ropes, branches and ladders (South Australian Government, n.d.). These methods encourage flying-foxes to work for their food and also helps to replicate foraging behaviour. This can also be achieved by changing or hiding the location of food.



Browse can be presented in water pots, or tied and hung from the enclosure roof or walls. Flowers can also be hung individually or as a bunch, or placed into the feeders mentioned above (South Australian Government, n.d.).

5.5 Sustainability aspects of feeding including food security

Purchasing fresh fruit and vegetables from local farms / orchards can help to reduce the carbon emissions involved in transportation. This often means changing their diet with the seasons, instead of buying out-of-season fruits from interstate/overseas. Food items and supplements with a long shelf-life can also be purchased in bulk and stored for later use.

Food intake should be monitored as a way of limiting food waste. The quantity can then be reduced or certain items omitted if they are not being eaten.

During food preparation, scraps and peels can be collected for composting. Grey-headed flying-foxes produce a large amount of food waste when eating, so if possible this too can be collected and composted.

6 Handling and Transport

6.1 Timing of Capture and Handling

The grey-headed flying-fox is more easily caught during the day if kept outside, or during 'lights on' if kept in a nocturnal house (Jackson, 2007). They are a nocturnal animal, so they are roosting and generally less mobile during this time. If the capture is being performed in a public display enclosure, it may also be best to time the capture so that it happens in the morning prior to the park opening. This will ensure that there are no unnecessary onlookers, making the capture less stressful for both keeper and animal.

6.2 Catching Equipment

Catching bags are not recommended for megachiropterans (Jackson, 2007), including the grey-headed flying-fox. A more appropriate transportation carrier is a front opening small animal crate. The crate should be modified to include a wire mesh top, so the occupant can hang upside. The crate should be large enough the bats head and body are elevated (Jackson, 2007). This type of carry box can be used for both short and long-term transportation, as it provides a secure environment where the bat is unable to injure itself.

6.3 Capture and Restraint Techniques

All staffed involved in any sort of restraint or capture, must be fully vaccinated against rabies/lyssavirus. The utmost care must be taken during the capture of the grey-headed flying-fox due to their delicate wing bones that can be easily broken. An appropriate method should be chosen based on how well conditioned the induvial is to being handled.

Methods for capture are commonly physical but can also be mechanical. For example, a food trap can be created by feeding bats in a small enclosed area with a mechanical door that can be closed to trap occupants inside (Jackson, 2007). This method is recommended as it does not invoke stress and limits the potential for injury. Physical capture methods include the use of a hoop net, a towel or your hands (Jackson, 2007). Regardless of the method, capture should be done as quickly as possible to minimise stress and reduce the risk of panicked bats overheating or becoming injured.

Grey-headed flying-foxes that are not used to handling may screech loudly, wriggle or even try to bite when restrained. Due to the potential for disease transmission (lyssavirus), it is advisable to wear thick gloves and long sleeves when restraining bats that are not conditioned to handling (Jackson, 2007). Alternatively, a towel can be used to wrap around the bat which assists in restraining and reassuring the animal, by making it feel more secure.

Megachiropterans must always be restrained using two hands. One hand to hold the feet, while the other wraps around either the body/wings, or the shoulders/head – if it is a particularly bity animal.

6.4 Weighing and Examination

Flying-foxes can be weighed in a few different ways. The easiest method is to place the bat inside a transportation crate and place this on a set of electronic scales. The weight of the box can then be subtracted to determine the official weight. Bats that do not respond well to crating instead can be placed inside a cloth bag and weighed using hanging scales (Jackson, 2007).

For examinations, restraint techniques like those outlined above (7.3) will need to be implemented. Physical exams should look at the eyes, ears, teeth, body, legs and wings, including fingers and thumbs (Jackson, 2007). They should be thorough, but performed as quickly as possible, to reduce stress.

6.5 Transport Requirements

6.5.1 Box Design

The transportation box should be large enough for the occupant to move around freely and roost normally (IATA, 2016). For the grey-headed flying-fox, it is recommended to be a minimum of 30cm (w) x 30cm (l) x 40cm (h), regardless of the duration of travel (Jackson, 2007). However, the box design will vary greatly depending on the type of transportation.

At Animals of Oz, we use a pet carrier that is 36cm (w) x 55cm (l) x 42cm (h). This type of carrier is suitable for short duration travel, where handling is only performed by vaccinated keepers. The crate is rigid in design with good ventilation, and the roof is modified to include a wire lining for roosting.

Figure 1: an example of the type of animal crate used at Animals of Oz.

For airline travel, or any other form of travel that could involve handling of boxes by non-vaccinated people, a specially designed carry box must be used to prevent any chance of contact. This includes an internal wire crate, with a solid outer container (IATA, 2016). This is designed to prevent contact with workers and the escape of any animals during feeding or examination (IATA, 2016). It must withstand the rigors of transportation, with the safety and well-being of both animal and human paramount.

The outer frame must be impact-resistant, non-crushable and weatherproof (IATA, 2016), and designed to prevent the internal container moving around inside. A hinged door at one side must be provided. Suitable construction materials include wood, plywood, wire, wire mesh, non-toxic plastics, aluminium and resistant thermo-plastic (IATA, 2016). Ventilation holes should be mesh-covered, preferably 1-2cm in diameter, covering 10% of the surface area on at least three sides (IATA, 2016). Handles should also be included on three sides of the outer container.

6.5.2 Furnishings

Carry crates should include thick wire mesh at the top, for the bat to roost. This can be fitted inside a plastic pet carrier, or it can be constructed as the roof, which also allows good ventilation. Lining the bottom with newspaper helps to collect waste, and makes cleaning up easier.

6.5.3 Water and Food

For short duration trips, particularly those that occur during the day, the provision of food and water is not necessary. For longer duration trips, particularly in hot weather, water should be provided. This can be given in a small drip bottle that is securely fasten within the enclosure. Food can also be provided for long duration travel. But be mindful that flying-foxes have a very short digestive tract. So only small amounts of food should be given, to reduce the amount of waste that will build up in their travel box. Food can be provided in a small plastic or stainless-steel bowl that is securely fastened to the wall or door, to prevent it moving around, spilling or causing injury.

6.5.4 Animals per Box

Like all megachiropterans, the grey-headed flying-fox should be housed singularly for transportation, except in the case of mothers and their dependent offspring. This minimises risks relating to fighting or accidental injury. In extreme circumstances, multiple flying-foxes may be transported together for short durations.

6.5.5 Timing of Transportation

Bats can be transported at any time. However, ideally it is done during the cooler parts of the day and when they are normally roosting (Jackson, 2007). This is the preferred time to transport them, as they will be less active and more tolerant to being cooped up.

6.6 Release from Box

Grey-headed flying-foxes can be removed from their carry box or allowed to leave in their own time (Jackson, 2007). For the latter, it is important to place the box open on the ground, but next to an object or surface that they can climb. Alternatively, catch and restrain the bat from within the transport box and release it back to its preferred roosting position. Ensure it has a good grip with its feet, before releasing the rest of its body to prevent injury.

6.7 Sustainability

Good quality transportation crates / containers should be purchased, so that they can be reused many times and will not degrade as quickly – then needing to be replaced.

Transportation should be planned so that the most economical and environmental method can be chosen. For example – choosing the shortest possible route or ‘greenest’ mode of transport, so as to reduce carbon emissions.

7 Health Requirements

7.1 Daily Health Checks

Grey-headed flying-foxes should be observed daily for signs of illness or injury. Observations are generally undertaken during cleaning and feeding. These daily health checks should be performed once a day, at a minimum. The following should be assessed for all individuals:

- Coat condition – is it dry and well groomed, or wet with poor fur condition (note, they may have just taken a urine bath and this is not cause for concern)
- Limbs – do all limbs appear to be moving freely? Are they holding/wrapping their wings normally or do they appear restricted or asymmetrical? Look for tears to the wing membrane and possible broken bones.
- Feeding – are their food bowls full or empty and licked clean? Are they waiting at the enclosure door or hanging above food bowls in anticipation of food?
- Discharge – the eyes, ears, nose mouth and anus should be clear. Any nasal, ocular or cloacal discharges should be noted.
- General appearance - body condition and condition of coat.
- Changes in behaviour – are they relaxed or anxious? Are they asleep or awake/alert? Are they with or apart from the group? Are they making unusual sounds or vocalisations?
- Faecal material - is it the normal colour/consistency or does it contain blood?

7.2 Detailed Physical Examination

Physical examination of the grey-headed flying-fox is important for diagnosing health issues. Simple examinations that can be performed include:

- Body condition – check muscle condition over the scapula, spine and skull.
- Weight – record and compare to previous weights, as weights can vary greatly between individuals depending on age, sex and geographic location.
- Fur – look for hair loss (alopecia), signs of trauma and presence of ectoparasites.
- Eyes – should be clear, bright, and alert, with no discharge. Can also check for light response and corneal reflex.
- Anus – should be clean. Faeces around the anus can indicate diarrhoea or improper toileting that could be a sign of illness or injury.
- Temperature – can be taken using an anal thermometer and should be 37-39˚.
- Respiration rate – rapid, shallow or loud breathing could be cause for concern.
- Pulse rate – 100-400 beats per minute is normal for the grey-headed flying fox.
- *For males, also check the penis and testes (size and consistency)

These checks can be performed without aesthetic, while the animal is conscious but restrained. However, grey-headed flying-foxes are often anesthetised if they are to be handled by veterinary staff who are not vaccinated, due to the risk of contracting lyssavirus.

7.3 Routine Treatments

Grey-headed flying-foxes can be wormed if they have contracted intestinal worms. It is uncommon to routinely worm bats at a preventative but it can be done. There are also no routine or other vaccinations given to bats to prevent the contraction of disease. However, researchers are currently working on a Hendra Virus vaccine, that will be suitable for use on flying-foxes.

7.4 Known Health Problems

Bats suffer very few health problems in captivity but some common known health problems for the grey-headed flying-fox have been presented below:

8.4.1 **Ectoparasites** –

Ectoparasites are rare in captive bats and even if introduced, usually disappear on their own after a short amount of time. Ectoparasites that have been observed in captive GHFFs include Nycteribiidae and Streblidae (also known as ‘bat flies’), fleas, ticks and mites (Jackson, 2007).

Symptoms: ectoparasites can cause skin irritation and itching causing scabbed or flaky skin and even hair loss.

Diagnosis: ectoparasites can often be observed on the body during examination. However, mites sometimes require skin scrapes and microscope examination to confirm presence.

Treatment: Some ticks are known to cause paralysis and should be removed immediately by a veterinarian or trained keeper, taking care to fully remove the head. Mites can be treated with Frontline Top Spot, by placing a single drop at the back of the neck of all affected bats. Flea powders are also safe to use on bats, and some low irritant pyrethrum sprays can also be sprayed around the enclosure to get rid of parasites (Jackson, 2007).

Prevention: ectoparasites are rare and usually do not require ongoing preventative methods. But Ivermectin can be used if ectoparasites are of particular concern (Jackson, 2007).

8.4.2 **Endoparasites** –

Endoparasites infrequently occur in captive flying-foxes, and those that do rarely cause any problems. Some known endoparasites that affect the GHFF include Toxocara pteropodis (Ascarid Nematode), Ringworm, Roundworm and Angiostrongylus cantonensis (Rat Lungworm) (Jackson, 2007).

Symptoms: endoparasites can cause a range of symptoms including loss of weight or failure to put on weight, diarrhea, abdominal pain and/or swelling. Rat Lungworm is also known to cause neurological issues such as partial paralysis to the limbs and extreme weight loss.

Diagnosis: fecal flotation is used for most gastrointestinal parasites.

Treatment: GHFFs should be wormed on arrival at a new facility. A common wormer used is Felex paste (at a dose of 1ml per kg body weight). This can be administered orally or smeared on the fur, as the bat will then lick this off during grooming (Jackson, 2007).

Prevention: prevent the access of rodents, slugs and other parasite carrying animals into the enclosure. Routine worming can also be done if endoparasites are of particular concern.

8.4.3 Viruses

8.4.3.1 Australian Bat Lyssavirus –

Lyssavirus is a rabies-like serotype, first observed in bats in 1996. The grey-headed flying-fox is one of six species, known to carry the disease in Australia. ABLV is a zoonotic disease and can therefore be passed on to humans. While it is estimated to be found in less than 1% of wild bats (and far fewer captive bats), there is no cure for ABLV and it is therefore fatal for both bats and humans.

Symptoms: ABL can sub-clinically affect some infected bats, and though still carriers they will be asymptomatic. Clinically affected bats can present with a range of symptoms including an inability to fly, partial paralysis of the hind limbs, general body weakness and progressive neurological change resulting in sudden aggression, frothing at the mouth, back arching, abnormal vocalisation and difficulty swallowing (Jackson, 2007).

Diagnosis: at present, the only definitive method of diagnosing the virus, is through testing of the brain tissue. All bats suspected of carrying the disease must therefore be euthanized.

Treatment: ABLV is incurable and untreatable. Affected bats should be euthanized immediately.

Prevention: captive bats should be housed in enclosures that are double wired to prevent contact with wild bats. All keepers/handlers should be vaccinated. If a captive bat does appear to be infected, it should be euthanized immediately and the enclosure should be thoroughly cleaned with a veterinary grade disinfectant.

8.4.3.2 Hendra Virus –

Hendra was first discovered in 1994, after the death of a number of horses. A stable hand and trainer also became infected, and the trainer later died of respiratory and renal failure. Flying-foxes, including the GHFF, can sub-clinically carry Hendra virus. However, bats are not thought to be the direct source of the disease and all cases of human infection appear to have been contracted from horses. Hendra virus is not considered highly contagious (Jackson, 2007).

Symptoms: no gross pathology or history of attributable illness has been detected in infected flying-foxes.

Diagnosis: at present, Hendra virus has only been confirmed in already deceased bats, using an indirect immunofluorescence test.

Treatment: there is no known treatment, however research continues to find a vaccine suitable for use on cats, horses and flying-foxes.

Prevention: captive bats should be housed in enclosures that are double wired to prevent contact with wild bats. Captive populations can be regularly tested if there is concern, for example – if Hendra Virus is known to be prevalent among wild populations in the area.

8.4.4 Wing membrane infection –

Wing membrane infections are commonly called 'slimy wing' and they occur as a result of fungal infection, particularly that of the strain candida. Slimy wing occurs when flying-foxes are not given adequate access to fresh air and sunlight, or because they are unable to flap their wings properly.

Symptoms: slimy wing presents as creamy coloured patches on the wing, that have a slimy feel and bad odour. If left untreated, they can cause serious wing damage and even death.

Diagnosis: usually diagnosed by visual examination of the affected area and a microscopic examination of the fungus.

Treatment: the infection can be treated with topical ointments (Iovone, Conofite or Panalog). If treating with a spray, the wings should be dried thoroughly afterwards using a soft towel. In serious cases, oral antimicrobial drugs may also be prescribed.

Prevention: allow access to sun, fresh air and space to flap their wings.

8.4.5 Alopecia

Alopecia describes a number of conditions resulting in hair loss, in a single area or multiple areas of the head, face or body. It can be caused by ectoparasites or vitamin/mineral deficiencies.

Symptoms: fur loss on any part of the body, commonly around the eyes/face.

Diagnosis: can be diagnosed through visual signs.

Treatment: areas of alopecia can be treated with a Mycex wash. It is also very important to treat the cause of the alopecia. Look for and treat any ectoparasites and examine the diet and rectify any possible deficiencies.

Prevention: provision of an adequate diet and the early treatment of any ectoparasites that may occur.

8.4.6 Tears to the wing membrane

The delicate wing membrane of the grey-headed flying-fox can be damaged as a result of fighting and contact with rough surfaces or sharp objects.

Symptoms: obvious tears or holes (of any size) in the wing membrane.

Diagnosis: visual examination.

Treatment: holes and tears to the wing membrane can take anywhere from several weeks to several months to heal. Small tears and most holes can often heal on their own, but treatment with a weak disinfectant (such as Betadine) or an antibiotic solution is advised, to prevent infection. Large tears are unlikely to heal, unless the tissue is reattached as soon as possible. This can be achieved by gluing the torn membrane, using a tissue adhesive, such as VetBond, every 1cm along the tear. Sutures are not recommended to treat holes or tears.

Prevention: ensure that there are no sharp or rough surfaces that may catch the wing. Separate bats if fighting is severe and ongoing, likely to cause significant damage.

8.4.7 Tears to the ears

Damage to the ears generally occurs as a result of fighting.

Symptoms: single or multiple tears to one or both ears.

Diagnosis: visual examination.

Treatment: tears to the ears should be treated using an antibiotic cream.

Prevention: as they usually occur through fighting, they are difficult to prevent. If fighting is severe and ongoing, bats should be separated to prevent the ongoing occurrence of injuries.

8.4.8 Fractures

Fractures can result from a number of causes including, but not limited to, falls, collisions, fighting and mishandling.

Symptoms: fractures can present in many ways, depending on the cause and extent of injury. Common symptoms include general tenderness to the area, an inability to use or properly extend arms or legs, swelling at the joints and protruding bones.

Diagnosis: suspected fractures should be x-rayed to confirm the type and extent of damage.

Treatment: some fractures can be stabilized using bandages and/or splints. Others will require surgery, to reset and/or pin the bone. Fractures involving joints rarely heal correctly, and in rare cases bats may need to be euthanized if the fracture will significantly impact their quality of life.

Prevention: trauma can be prevented ensuring enclosures have adequate climbing structures and that the flight area is free from obstacles that may result in collisions. It is also important to train all keeping staff on correct handling techniques.

7.5 Quarantine Requirements

On admission to quarantine, bats should be given a detailed physical examination, as outlined in 8.2. During their time in quarantine, bats should be observed closely to look for signs of ill health. This may include physical or behavioural changes. There are no specific tests that need to be ordered, unless a bat is showing signs of one of the known health problems outlined above.

Bats that are brought into care for rehabilitation are usually quarantined in isolation cages for a minimum of three days, to observe for signs of ABL (Wade, 2013). In a captive environment, it is ultimately up to the facility as to how long they choose to quarantine their new arrival/s. The standard for many species, within the industry is 30 days (Jackson, 2007). However, given that GHFF carry diseases that will often present immediately or not at all, a facility may choose to cut this time short. Due to their highly social nature, grey-headed flying-foxes should not be housed alone for extended periods. Quarantine time should therefore be kept to a minimum.

8 Behaviour

8.1 Activity

Grey-headed flying-foxes are nocturnal, meaning they forage almost exclusively at night (Hall & Richards, 2000). During the day, they hang upside down in trees within their camp, where they sleep, groom, socialize and move around. This activity cycle reduces their risk of being attacked by avian predators (Hall & Richards, 2000). At night however, they are known to travel large distances, up to 100km, in search of food. The primary mode of transport for the grey-headed flying-fox is flying. Flying-foxes leave their camps in a mass exodus, shortly after dark. Mega-bats like the grey-headed flying-fox, do not use echolocation. Instead they rely on their sight and smell to travel around and locate food (Jackson, 2007).

8.2 Social Behaviour

Grey-headed flying-foxes are highly social species that roost together in 'camps'. The social structure within these camps is very complex, and individuals will often separate into smaller social units within the large colony (Jackson, 2007). These social units vary depending on the season. In captivity it is recommended that grey-headed flying-foxes be kept in groups. The ideal ration of sexes is three females to every male (Jackson, 2007). However, it is common for zoological facilities to keep them in same sex groups to prevent unintended breeding.

8.3 Reproductive Behaviour

During the breeding season, male grey-headed flying-foxes gain weight, and become increasingly aggressive, more vocal, and more odorous (Jackson, 2007). They exhibit increased scent marking behaviour, by rubbing on objects within their territory using secretions from their shoulder glands.

The two sexes may segregate within the colony, forming groups of mature male, mature females, and juveniles. After mating, pregnant females also separate from the colony and congregating in maternity groups, usually in areas of least disturbance (Hall & Richards, 2000). This is important for the birth and care of their offspring, which they raise in a 'creche' type environment with other mothers and babies.

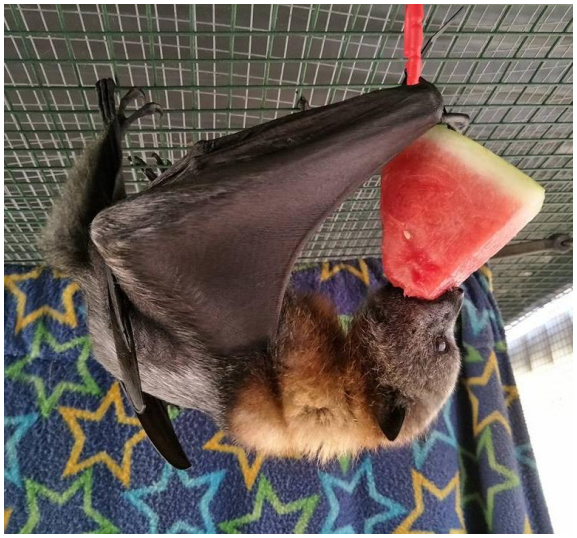
8.4 Behavioural Problems

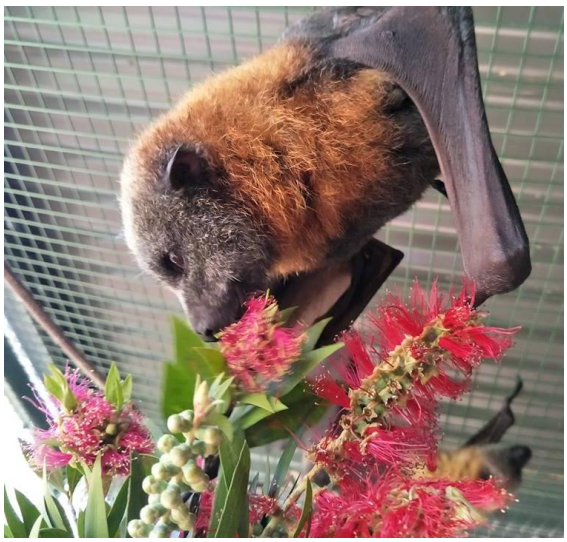
There is very little information available regarding behavioural problems in captive grey-headed flying-foxes.

8.5 Signs of Stress

Signs of stress in the grey-headed flying-fox can include excessive vocalisations, fear-aggression, social isolation, disinterest in food and/or weight loss (Jackson, 2007).

8.6 Behavioural Enrichment





Grey-headed flying-foxes are intelligent animals and enjoy many forms of enrichment. Examples of enrichment include:

Feeding –

- Offering a diversity of fruit within their diet
- Offering natural foods such as flowers and blossoms
- Offering novel food items such as sweet corn
- Providing food puzzles or interactive feeders
- Preparing their diet in different ways e.g. making fruit skewers or hanging whole fruits

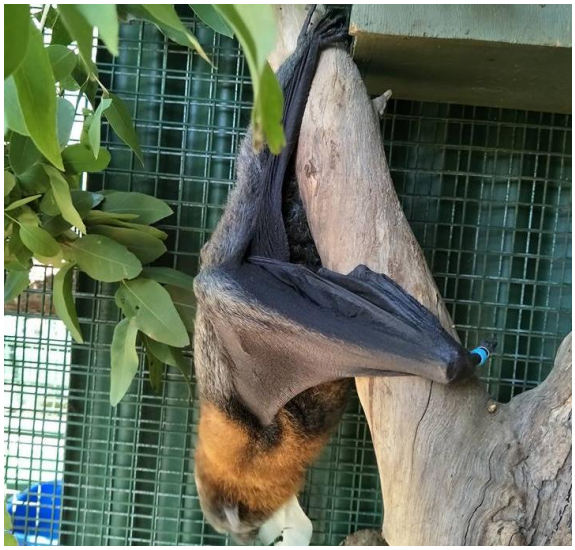
Social –

- Housing grey-headed flying-foxes in groups
- Social interactions with keepers
- Hanging mirrors in their enclosure
- Hanging comforter toys such as stuffed animals

Behavioural –

- Hanging toys rattles, bells or other musical toys in their enclosure
- Providing a variety of climbing opportunities e.g. ropes, ladders, branches, blankets.
- Hanging scented plants, sprinkling herbs or spraying perfumes for olfactory enrichment
- Providing adequate space/passage for them to make short flights
- Providing sprinklers for bathing, particularly on hot days
- Doing behavioural training, such as target or station training, or teaching them to perform natural behaviours on cue – such as wing spreading or vocalisations.

(Hall & Richards, 2000; Jackson, 2007; SA Government, n.d.; and Wade, 2013)



8.7 Introductions and Removals

Care should be taken when introducing flying-foxes, particularly if introducing a single individual to an already established group. Any introductions should occur at the beginning of the day, so that keepers can observe the animals closely and attend to any problems (Jackson, 2007). Fighting and bickering is common, particularly among males, as they try to re-establish their territories and social hierarchy within the group. In some instances, it may be useful to introduce new bats by placing them in a smaller holding pen within the larger enclosure (Jackson, 2007). This allows them to familiarise themselves with the area and other bats, in a safe and confined space.

8.8 Intraspecific Compatibility

The grey-headed flying-fox is a highly social species, and as such should never be housed alone. They can be housed in small or large groups, of mixed or same gender. It is however important to provide adequate space, enclosure furniture and roosting opportunities to minimize conflict within the group (Jackson, 2007).

8.9 Interspecific Compatibility

Grey-headed flying-foxes can be housed with other species, however aggressive encounters – particularly over food – are known to occur (Jackson, 2007). Given a large area, it is possible for gliders and other arboreal species, such as possums, to cohabitate. At Animals of Oz, we house our grey-headed flying-foxes in a mixed species enclosure with a kookaburra and small colony of sugar gliders. It is generally not recommended for flying-foxes to be housed with terrestrial species. This is due to the large amount of waste that they produce, having the potential to cause health problems for ground-dwelling species (Jackson, 2007).

8.10 Suitability to Captivity

The grey-headed flying-fox is well adapted to life in captivity. They can be maintained in a captive environment with relative ease and will breed readily if allowed to do so (Jackson, 2007).

9 Breeding

Grey-headed flying-foxes are placental mammals. As the only flying mammals, bats have a very unique reproductive system. Female flying-foxes give birth upside-down, within the trees of their roosting camps. They must use their wing as a safety net, in case the baby falls during the birthing process, and the umbilical cord acts as an additional safety line. Grey-headed flying-foxes generally give birth to a single offspring, who attaches to the teat and clings tightly to the mother for the whole first week – even during flight. These unique mammals form 'maternity groups' when the young are born. When the weight of their offspring becomes too great of a burden, the mothers must leave their offspring in a baby bat 'creche' (all together), while they fly out in search of food (Parish, Richards & Hall, 2012).

Figure 1: a baby grey-headed flying-fox clings to its mother during flight.

9.1 Mating System

As is the case with most flying-fox species, the grey-headed flying-fox is polygynous.

9.2 Ease of Breeding

Flying-foxes breed well in captivity, particularly those that are housed outside. While it is possible to breed flying-foxes that are housed in indoor enclosures, long-term exposure to altered light cycles (such as those in nocturnal houses) has been shown to decrease breeding activity (Jackson, 2007).

9.3 Reproductive Condition

The sexes of the GHFF are easy to distinguish. The reproductive condition of each is examined by looking at changes to the shape and size of reproductive features.

9.3.1 Females

During the breeding season, the female's vagina undergoes changes in response to sex hormones. Their reproductive state can be determined exactly from doing vaginal smears (Hall & Richards, 2000).
Gentle palpitation of the female's abdomen can determine pregnancy. This is easiest done before feeding – so there is no confusion caused by a full stomach (Jackson, 2007).
Flying-foxes are mammals and therefore feed their young milk. Before giving birth, their females' nipples are small and dome shaped. During lactation they increase in size and hair loss or changes to pigmentation in the surrounded skin is common. Even after lactation has subsided the area will remain wrinkled and darker in colour (Jackson, 2007).

9.3.2 Males

The reproductive anatomy of male bats is similar to other placental mammals. They have external reproductive organs including a distinct penis and scrotum. The epididymal sac, which is used to store sperm, increases in size in preparation for mating and is a good indicator of reproductive condition (Jackson, 2007).
During the mating season, male flying-foxes attract females by scent marking, using secretions from their shoulder glands. Thru courtship they lick the female's urogenital area and if receptive, mating occurs. The protruding penis is significantly long for this species, because males mount the females from behind. The penis must therefore reach under the hind legs and tail membranes in order to copulate. The males hold the females by biting into the back of their neck and as always, mating occurs entirely upside-down (Parish, Richards & Hall, 2012).

9.4 Techniques Used to Control Breeding

The most common technique used to control breeding is the separation of sexes. Contraceptive implants are also being developed and have been trialled on other flying-fox species with some success. The implants do not appear to affect social behaviour. However, 22% of implants were rejected and physical affects were observed such as weight gain and alopecia at the implant site (Jackson, 2007).

9.5 Occurrence of Hybrids

In the wild, hybridization is believed to have occur between the grey-headed flying-fox and the black flying-fox (Pteropus alecto).

9.6 Timing of Breeding

The grey-headed flying-fox has only one breeding season per year. Mating usually occurs between March and April, with offspring being born between September and November. Some variation in timing exists between geographic locations, as the species is so widespread. Timing of breeding is believed to be largely determined by the changing day length. However, the timing and success of the breeding season is also heavily influence by environmental factors such as climatic variation and food availability (Parish, Richards & Hall, 2012).

9.7 Age at First Breeding and Last Breeding

Females reach sexual maturity at 16 months of age, with males taking significantly longer at 30 months of ages. Females usually breed in the second breeding season of their life, when they are 1-2 years of age. Males usually breed at three years of age, they may attempt to mate earlier but it will likely be unsuccessful (Hall & Richards, 2000). The age of last breeding is not well known.

9.8 Ability to Breed Every Year

Grey-headed flying-foxes are able to breed every year and will do so in the wild. They also breed very well captivity, and will breed year after year, if kept in the right conditions (Jackson, 2007).

9.9 Ability to Breed More than Once Per Year

The grey-headed flying-fox is only able to breed once per year.

9.10 Nesting, Hollow or Other Requirements

There are no specific roosting requirements for captive flying-foxes.

9.11 Breeding Diet

There are no specific guidelines for the breeding diet of the grey-headed flying-fox.

9.12 Oestrous Cycle and Gestation Period

Female flying-foxes ovulate from late February to early April. The gestation period is known to be approximately 180 days. Lactation lasts for around 6 weeks, after such time the female is again receptive to males (Hall & Richards, 2000).

9.13 Litter Size

Grey-headed flying-foxes give birth to a single offspring. Twins are possible but extremely rare.

9.14 Age at Weaning

Grey-headed flying-foxes are weaned at 5-6 months of age.

9.15 Age of Removal from Parents

Once they are weaned, juveniles can be removed from their parents but generally they are left with their colony, as would occur in the wild. If young are to be removed after weaning, it should not be assumed that they are fully weaned just because they can fly as some overlap can occur.

9.16 Growth and Development

Baby grey-headed flying-foxes are born fully furred and with their eyes open. They usually weigh around 75g – with birth weight being largely influenced by food availability during the pregnancy (Jackson, 2007). The growth and development of babies should be monitored, with weekly weigh-ins and body measurements taken.
Measurements:

- Weight (g)
- Body length (mm); measured from nose to tail
- Forearm length (mm)
- Hind leg length (mm)

The development of the grey-headed flying-fox can also be assessed by monitoring that they are reaching developmental milestones such as fur growth, teeth growth, self-hanging, eating solids, wing flapping, self-feeding, ability to fly etc. These developmental stages should be recorded and compared to known growth curves – if available (Jackson, 2007).

10 Artificial Rearing of Mammals

Orphaned grey-headed flying foxes being cared for by Wildlife Victoria. Photo: Alex Coppel, Daily Mail.

10.1 Housing

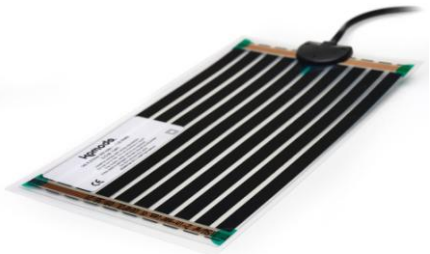
The ideal environment for the artificial rearing of the grey-headed flying-fox is one with minimal stress. This is achieved by ensuring that the area is warm, quiet, secure and free from hazards (Jackson, 2007). As baby grey-headed flying-foxes grow and develop, their housing needs greatly change.

Until about six weeks of age, baby flying-foxes can be kept inside a small pet carry cage (Bat Conservation and Rescue, 2014). The cage should be covered with a tight-fitting, breathable cover (an old t-shirt is suitable) to prevent damage to the baby's delicate wings, caused by poking them through the wire.

During their first weeks they will spend most of their time wrapped in a blanket. As they get older they will start to explore and climb around the cage, eventually needing more room to move. From approximately 6 weeks of age, a large bird cage or clothes airer can be used as 'housing' (Bat Conservation and Rescue, 2014). Draping fleece blankets provides a place for the developing baby to hang, climb and explore. Hanging a towel underneath can also act as a net in case they fall. Eventually the juvenile bat will need to be moved into an outside aviary where they can learn to fly.

10.2 Temperature Requirements

Baby flying-foxes should be kept at approximately 28˚C until they are 'furred' (approximately four weeks of age), as they are unable to thermoregulate (SA Gov, n.d.). This can be achieved using a hot water bottle, heat lamp or heat mat (Jackson, 2007). Whichever method is chosen, it is very important to ensure that there is no risk of overheating or burning from the heat source. A max-min thermometer and/or thermostat can be used to monitor and regular the temperature.



10.3 Diet and Feeding Routine

Grey-headed flying-foxes are not lactose intolerant, unlike other Australian mammals such as marsupials (SA Gov, n.d.). Fortunately, this means there are a number of formula options available for hand-rearing. The preferred option is Wombaroo Flying-fox Milk Replacer. This formula is specially formulated to match the milk composition of the flying-fox and is the best option for babies of all ages, from birth to weaning. If unavailable, other options include Divetelact (*Sharp*), Nan 1 or 2 (*Nestle*) infant formula or Complan (*Galaxo*) milk powder (Jackson, 2007; SA Gov, n.d.).

Milk is supplied using a 10ml syringe, and an artificial teat. Wombaroo make teats specifically for flying-foxes, alternatively teats made for possum-sized marsupials or small dogs can also be used. Using a syringe is important to control the milk flow and allows close monitoring of quantities being fed.

Orphaned grey-headed flying foxes being cared for by Wildlife Victoria. Photo: Alex Coppel, Daily Mail.

Before feeding it is important to ensure that the baby bat is warm bodied and fully awake. Feeds are best done when the baby is wrapped in a blanket or towel, so that the wings and feet are restrained. The bat should be held on its side (with its back against the carer) and its head slightly lower than its feet, to reduce the risk of milk inhalation (Jackson, 2007).

Before and after every feed, the baby bat should be inverted, and the genital area wiped gently with a ball of cotton wool dipped in warm water. This stimulates urination and defecation.

At first, feeds should be given every 2-3 hours. However, this can be reduced gradually over a few weeks until no night feeds are needed – and eventually only four feeds a day are required. At seven weeks of age baby grey-headed flying-foxes can be introduced to pureed fruits (apple is preferred) in between feeds. By three months of age, the bat should be consuming two bottle feeds per day, in addition to 200g of chopped mixed fruit, sprinkled with 10g of flying-fox milk replacer powder.

10.4 Specific Requirements

As a flying mammal, the development of baby flying-foxes' wings are very important. Newborn babies should be given a small amount of gentle exercise (including wing extension) after every feed. At three weeks of age, baby bats start to become more active and must be allowed to climb, stretch and flap their wings (Jackson, 2007).

At 12 weeks of age, baby bats should be learning how to fly. It is essential that they are encouraged to fly at this age or they may never master this important skill (Jackson, 2007). Flying can be encouraged in a captive environment by placing them outside in a large aviary and calling them from a distance. To reduce the risk of injury, blankets and leafy branches should be hung around the inside perimeter of the enclosure to cushion their landings.

10.5 Data Recording

Regular health checks and data collection are important in monitoring the wellbeing of baby bats. When an animals is taken in for hand-rearing it should be immediately ID'd – given a name, sexed and the approximate age (or DOB if known) recorded.

Recording information assists in both monitoring growth and development and identifying health issues. Information that should be recorded includes:

- Date & time of recording
- Amount of food offered
- Amount of food consumed
- Frequency of urination/defecation
- Body weight (to the nearest 1g)
- Any vet exams or test results
- General appearance, activity, demeanour etc (Jackson, 2007)

Signs of ill health in baby bats include vomiting and diarrhoea. In these instances, there is a risk of dehydration so 2 milk feeds per day should be replaced with a bottle of 5% glucose and water. If vomiting and/or diarrhoea continues for 4 or more feeds seek veterinary advice immediately (Bat Conservation and Rescue, 2014). Baby bats, like all young animals, are particularly vulnerable and can deteriorate quickly.

10.6 Identification Methods

Even if rearing multiple individuals, it is usually possible to tell them apart due to differences in size, colouration and markings. However, to make identification easy for carers, coloured nail polish can be used to uniquely paint their toenails until more permanent identification methods, such as chips or bands, can be implemented.

10.7 Hygiene

Any one working with flying-foxes in a captive environment should be maintaining high standards of personal hygiene. This is particularly important for those working with babies, to protect both the carer and the vulnerable pup from the spread of disease (SA Gov, n.d.). Keeper should wash their hands, before and after handling babies, before and after handling food, and whenever they come into contact with any bodily fluid.

Cleaning is very important to ensure the wellbeing of flying-fox pups. To maintain a safe and hygienic environment, carers should clean cages using a veterinary grade disinfectant such as f10. Bedding should be replaced regularly and washed using a sterilising agent. All feeding equipment should be washed between use, using detergent and/or sterilised using boiling water (SA Gov, n.d.).

10.8 Behavioural Considerations

Socialisation is vital for the development of ‘normal’ bat behaviour. Semi-weaned bats should be kept in small groups (with other hand-reared bats of similar age) to aide their socialisation and to reduce the risk of imprinting (Jackson, 2007).

10.9 Use of Foster Species

Grey-headed flying-foxes are not known to have been fostered by bats of the same or other species (Jackson, 2007).

10.10 Weaning

Grey-headed flying-foxes are weaned at around six months of age. Once weaned, juveniles should be housed together in 'nurseries' with other bats of similar age. This helps to improve socialisation skills and aids their adjustment to their eventual transition to living in an adult colony. Once they are fully weaned grey-headed flying-foxes should be able to consume the same diet as their adult counterparts (Jackson, 2007).

10.11 Rehabilitation and Release to the Wild Procedures

Grey-headed flying-foxes are ready for release once they are fully weaned. At this time, multiple juveniles should be placed together in a large aviary within seeing and hearing distance of the colony they are intended to join. They should remain in this 'release enclosure' for a minimum of 30 days to ensure that they have become accustomed to their surroundings and are adequately socialised (Jackson, 2007).

Bats that are returning to the wild should have minimum human contact during this time. When they are approximately 450g and have had sufficient flight practice, they are ready for release into the wild (Jackson, 2007). At this point, the top of the enclosure should be opened, allowing young bats to come and go as they please. Food is left out for a further eight weeks, after which time it is gradually reduced – a technique known as 'soft release'.

Bats bring released into a captive colony should be introduced as a group and closely monitored. Some bickering within the group is normal, however individuals may need to be separated if fighting persists or is violent enough to cause injury.

11 Collection Management

11.1 Current Collection Census and Plan holdings

The current Collection Census and Plan holdings for;

Common name: Grey-headed flying-fox
Class: Mammalia
Order: Chiroptera
Family: Pteropodidae

are attached (see page 56).

Organisation	Member Type	Males	Females	UNK	Planned Males	Planned Females	Planned UNK	Impl. Option	Impl. Category	Time Frame	TAG	Program Type	Last Edited	IUCN	CITES	VPC
Australia Walkabout Wildlife Park	Member-Associate Institutional	4	8	0	4	8	0	Maintain			Aust Mammals	NRP	11-11-14	VU	II	
Australian Reptile Park	Member - Full Institution	3	3	0	3	3	0	Maintain			Aust Mammals	NRP	13-06-16	VU	II	
Caversham Wildlife Park	Member - Full Institution	2	5	2	2	5	2	Maintain			Aust Mammals	NRP	09-12-17	VU	II	
Currumbin Wildlife Sanctuary	Member - Full Institution	0	8	0	0	8	0	Maintain			Aust Mammals	NRP	09-11-16	VU	II	
Darling Downs Zoo	Member - Full Institution	0	0	0	2	4	0	Acquire	Breed		Aust Mammals	NRP	15-09-11	VU	II	
Featherdale Wildlife Park	Member - Associate Institutional	0	1	0	0	0	0	Delete		Medium-term	Aust Mammals	NRP	28-12-17	VU	II	
Gorge Wildlife Park	Member - Full Institution	0	0	30	0	0	30	Maintain			Aust Mammals	NRP	05-02-08	VU	II	
Healesville Sanctuary	Member - Full Institution	8	0	0	0	0	0	Delete	Excess	Long-term	Aust Mammals	NRP	24-01-18	VU	II	
Lone Pine Koala Sanctuary	Member - Full Institution	3	8	0	3	8	0	Maintain			Aust Mammals	NRP	06-12-17	VU	II	
Moonlit Sanctuary	Member - Full Institution	0	0	0	3	3	0	Acquire			Aust Mammals	NRP	14-12-17	VU	II	
Peel Zoo	Member-Associate Institutional	0	0	0	1	1	0	Acquire		Short-term	Aust Mammals	NRP	17-12-17	VU	II	
Symbio Wildlife Park	Member-Full Institution	0	0	0	0	0	6	Acquire	for display	Medium-term (3-5 years)	Aust Mammals	NRP	05-12-16	VU	II	

Male	Female	UNK	P. Male	P. Female	P. UNK
20	33	UNK 32	18	40	38

11.2 IUCN Category.

The IUCN Category for the grey-headed flying-fox is vulnerable (VU).

VULNERABLE (VU): A taxon is 'Vulnerable' when the best available evidence indicates that it meets any of the IUCN criteria for Vulnerable, and it is therefore considered to be facing a high risk of extinction in the wild.

The GHFF is considered vulnerable due to continuing population decline, estimated to be more than 30% over the last three generations. This is largely due to loss of habitat, and probable competition and hybridisation with *P. Alecto*.

11.3 C.I.T.E.S. Appendix

The grey-headed flying-fox is listed under appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

APPENDIX II: These are species that, although not threatened with extinction now, might become so unless trade in them is strictly controlled and monitored. CITES Appendix II also includes some non-threatened species, in order to prevent threatened species from being traded under the guise of non-threatened species similar in appearance.

11.4 National Category

Under the Environmental Protection and Biodiversity Act (EPBC Act) the grey-headed flying-fox has a national listing of Vulnerable.

In 2017 a draft recovery plan was released for the grey-headed flying-fox. It aims to improve the national population trend by;

- Identifying, managing, and securing key foraging and roosting habitat.
- Encouraging an improved capacity to coexist with flying-foxes within the community.
- Increasing public awareness about species, the threats they face and the importance of the ecosystem services they provide as seed dispersers and pollinators.

Despite a vulnerable listing, the states of Queensland and New South Wales still permit, in certain circumstances, the use of lethal measures (shooting) for controlling flying-fox damage to crops. It is important to note that the Commonwealth Government does not promote these practices, and significant lethal actions have the potential to breach the EPBC Act and be subject to civil or criminal penalties.

11.5 State or Territory Categories

The grey-headed flying-fox is listed as Vulnerable under the New South Wales Threatened Species Conservation Act 1995. It is listed as Threatened under the Victorian Flora and Fauna Guarantee Act 1988 and Rare under the South Australian National Parks and Wildlife Act 1972. In Queensland this species remains listed as Least Concern under the Nature Conservation Act 1992.

11.6 Wild Population Management

Wild population management exists through the government's *Action Plan for Australia Bats*. This aims to:

- Stabilise the population at its 1999 numbers
- Identify and protect essential roosting and foraging habitat
- Develop non-destructive methods for crop protection
- Develop non-destructive methods of camp management in problem areas
- Ensure consistent management of the species across all state (QLD, NSW and VIC).

A national monitoring program for the grey-headed flying-fox also began in February 2013. It is the largest census of wild GHFFs ever undertaken across the species entire national range. Surveys were conducted every three months, with the aim of delivering a reliable benchmark on the 2013 population size. This will allow the government to monitor population trends into the future.

11.7 ASMP Category of management

The grey-headed flying-fox is listed as NRP under the Australasian Species Management Program.

No Regional Program (NRP): either not assessed or not currently deemed a regional priority for intensive management at this time.

11.8 Key Personnel

N/A

11.9 Captive Management details

N/A

11.10 Population Viability Assessment

A population viability assessment (PVA/ PHVA) has not been undertaken for the grey-headed flying-fox. Currently, 85 (20.33.32) individuals are held across eight ZAA member institutions. Four facilities are also hoping to acquire animals for their collection, with the total 'planned' across all institutions being 96 GHFFs (18.40.38).

There are enough founding members within the captive population for them to be considered sustainable/viable. However, two facilities plan to 'delete' their populations, one facility has all females (therefore unable to breed), and the other 5 are set to maintain. No-one has stated that they intend to breed, despite four other zoos/parks hoping to obtain 20 GHFFs between them.

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Glossary

Aesthetic – concerned with appearance or the appreciation of beauty.

Asymptomatic – (of a condition or a person) producing or showing no symptoms.

Arboreal – living in trees; or relating to trees.

Bi-maturation – a difference in developmental timing between males and females of the same species.

Cohabitate – the state of living together.

Ecological – relating to or concerned with the relation of living organisms to one another and to their physical surroundings.

Endemic – (of a plant or animal) native or restricted to a certain place.

Exodus – a mass departure.

Generalist – a species that is able to thrive in a wide variety of environmental conditions and can make use of a variety of different resources.

Gestation – the period of development inside the womb between conception and birth.

Hierarchy – a system in which members of a group are ranked according to relative status or authority.

Hybridization – the process of an animal breeding with an individual of another species.

Interspecific – existing or occurring between different species.

Intrasexual selection – when members of the same sex compete for access to members of the opposite sex.

Intraspecific – produced, occurring, or existing within a species or between individuals of a single species.

Nocturnal – done, occurring, or active at night.

Pathology – the science of the causes and effects of diseases, especially the branch of medicine that deals with the laboratory examination.

Quarantine – a state, period, or place of isolation in which animals that have arrived from elsewhere or been exposed to infectious or contagious disease are placed.

Serotype – a distinct variation within a species of bacteria or virus or among immune cells of different individuals.

Sexual dimorphism – distinct difference in size or appearance between the sexes of an animal in addition to the sexual organs themselves.

Sub-clinical – an infection that is nearly or completely asymptomatic (no signs or symptoms).

Sustainability – avoidance of the depletion of natural resources in order to maintain an ecological balance.

Thermoregulation – the ability of an organism to keep its body temperature within certain boundaries, even when the surrounding temperature is very different.

Zoonotic – a disease that can be transmitted from animals to people.

14 Appendices

14.1 Appendix 1 Products Mentioned in Text.

Complan (*Galaxo*) Milk Powder
https://www.pharmacydirect.co.nz/Complan-Powder-VANILLA-500gm.html

Divetelact (*Sharp*)
https://www.budgetpetproducts.com.au/new/product/di-vetelact-animal-supplement-900gm-divetelact/2118/

F10 SC Veterinary Disinfectant
https://www.vetnpetdirect.com.au/F10D

Nan 1 or 2 (*Nestle*) Infant Formula
https://www.chemistwarehouse.com.au/shop-online/2967/nan-infant-formula-0-6-months

https://www.chemistwarehouse.com.au/shop-online/2968/nan-follow-on-formula-6-12-months

Wombaroo High Protein Supplement (*HPS*)
http://www.aussievetproducts.com.au/products/wombaroo-high-protein-supplement

Wombaroo Feeding Bottle
https://www.vetnpetdirect.com.au/WOMBBTL#.UzovnWeKA5s

Wombaroo Flying Fox Milk Replacer
https://www.wildlifesupplies.com.au/shop/flying-fox-milk-replacer-140-gr.html

Wombaroo Teat F (for Flying Fox)
https://www.vetnpetdirect.com.au/WTEAT#.VCI9Y2ccTyd

14.2 Appendix 2 MSDS (Material Safety Data Sheets).

F10 SC Veterinary Disinfectant

> F10 SC is a hospital grade total-spectrum disinfectant. It is safe to use on a range of surfaces and has no adverse effects on people or animals. F10 SC kills all types of pathogens and is therefore considered bactericidal, fungicidal, viricidal and sporicidal. In Australia, f10 SC is registered by APVMA for use in facilities that house animals.

A Material Safety Data Sheet for F10 SC can be found at: https://www.vetnpetdirect.com.au/core/media/media.nl/id.197681/c.1032112/.f?h=3f696eb050e2891de2ae

F10 SC can be purchased from: https://www.vetnpetdirect.com.au/F10D

Liquid Bleach

> Liquid bleach is suitable for controlling mold and fungus, and can also be used for disinfecting, cleaning and bleaching. Bleach works by denaturing the proteins in micro-organisms. It is therefore effective in killing bacteria, fungus and viruses. Bleach is quick, effective and widely available at a low cost.

A Material Safety Data Sheet for Liquid Bleach can be found at: http://www.msdsonline.com.au/msds/msdsview.asp?Std=1&ID=9649d247-4f1b-4709-8954-de3d280e67ac

Liquid Bleach can be purchased from most supermarkets or cleaning supply stores.

White Vinegar

> White Vinegar can be used for cleaning, as a safer alternative to bleach. White vinegar is effective removing mold and degreasing surfaces. It can also be used as a disinfectant to tackle gram-negative bacteria such as salmonella and E. coli.

A Material Safety Data Sheet for White Vinegar can be found at: https://www.cos.net.au/msds/SAUC3010.pdf

White Vinegar can be purchased from the supermarket.