Husbandry Manual for the

Yellow-Bellied Glider
Petaurus australis

Mammalia : Petauridae

Liana Carroll

December 2005

Western Sydney Institute of TAFE, Richmond

1068 Certificate III Captive Animals

Lecturer: Graeme Phipps

TABLE OF CONTENTS

1 Introduction

The Yellow-bellied Glider is the largest Australian member of the family Petauridae and was classified by Shaw as *Petaurus australis* in 1791 as Australia's first gliding possum. It has a patchy distribution across the eastern and southeastern parts of Australia in wet and dry sclerophyll forests and woodlands.

The species is characterised by its dark to pale grey covering above with a darker stripe down the centre of the back. The belly ranges from whitish through yellow to orange with increased age and the gliding membrane extends from the wrist to the ankle. The distinctive ears are large, pink-grey and bare and its tail is long, broad and bushy. It is the most vocal of the Australian gliders and can be heard up to several hundred metres away.

The Yellow-bellied Glider is the least studied member of its family and very little data is available on this species in captivity.

Currently, wild populations of the Yellow-bellied glider are under threat. This is due to the destruction of their habitat through clearing and logging and predation by foxes and cats. In NSW the species is listed as vulnerable and the National Parks and Wildlife Service [NPWS] have released a recovery plan to ensure of its ongoing viability in the wild.

2 Taxonomy

2.1 Nomenclature

CLASS	Mammalia
ORDER	Diprontodonta
SUB-ORDER	Phalangeridida
SUPER FAMILY	Petauroidea
FAMILY	Petauridae
GENUS	*Petaurus*
species	*australis*

2.2 Subspecies

- *Petaurus australis australis* – eastern Australia from Portland Victoria to central coastal Queensland.

- *Petaurus australis reginae* – northern Queensland to western slopes of rainforest between Mount Windsor and Yamanie, on the bank of the Herbert River Gorge. [Russell 1995, p228]

2.3 Recent Synonyms

- None

2.4 Other Common Names

- - Fluffy Glider
  - Flying Glider
  - Dusky Glider

3 Natural History

The Yellow-bellied Glider is the largest exudate-feeding arboreal mammal in Australia and amongst the largest of this foraging class in the world [Henry & Craig 1984, p331]. Its anatomical characteristics are therefore adapted to arboreal dwelling and feeding. Some of these include: a gliding membrane, long claws, protruding incisors and a black dorsal camouflage stripe.

Petaurus australis jaw & skull
[Museum Victoria 2002]

Front claws of *Petaurus australis*
[Museum Victoria 2002]

To date, various studies have contributed to the biological knowledge of the Yellow-bellied Glider including: social behaviour and organisation [Craig 1985; Russell 1984]; litter size and reproductive strategy [Craig 1986]; diet and foraging behaviour [Goldingay 1986; Goldingay 1990; Kavanagh 1987; Henry and Craig 1984]; longevity [Slater 1997]; and calling behaviour [Goldingay 1994; Kavanagh & Rohan-Jones 1982].

3.1 Morphometrics

3.1.1 Mass And Basic Body Measurements

Head and Body Length
270 – 300mm
Tail Length
420 – 480mm
Weight
450 – 700g

3.1.2 Sexual Dimorphism

- Males are heavier and the northern race smaller. [Cronin 1991, p64]

3.1.3 Distinguishing Features

- The Yellow-bellied Glider is the largest Australian member of the family Petauridae and the second largest glider in Australia.

- The head and body is much longer than that of the Sugar or Squirrel glider but shorter than in the Greater Glider.

- Tail is relatively longer [approx. 1.5 times the body length] than in other gliders.

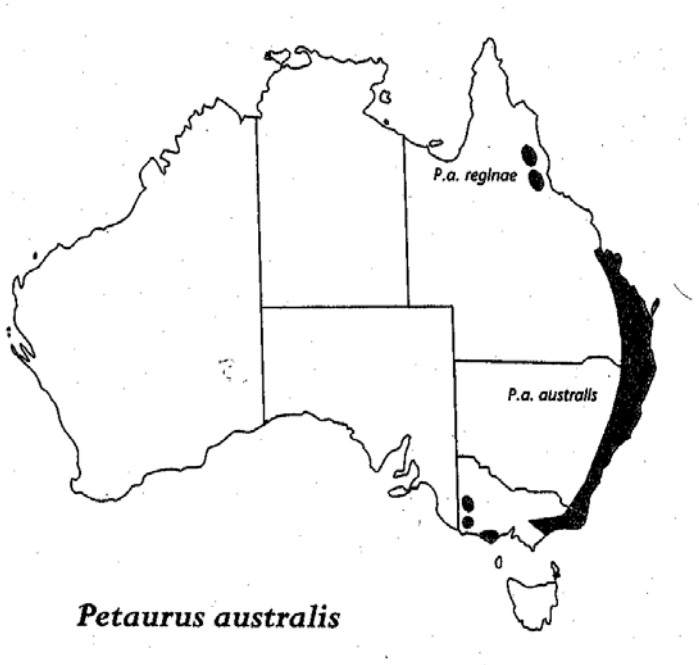
- A characteristic feeding habit of the species is incising 'V' shapes into the trunks of eucalypts to obtain sap.

- It is the most vocal of all the Australian gliders

3.2 Distribution and Habitat

- Distribution is patchy across a wide range of eastern and southeastern areas of mainland Australia. The southern subspecies *P.a. australis* occurs along the east coast of Australia to central Queensland and the northern subspecies *P.a. reginae* occurs in two small populations in north Queensland. [Russell 1995]

- In NSW its distribution is essentially coastal, extending inland to adjacent ranges. [NPWS 2003]



[Russell 1995, p228]

- Preferred habitats are productive, tall, open sclerophyll forests where mature trees provide shelter, nesting hollows and year-round food resources. A predominance of smooth-barked eucalypts within a mixed eucalypt forest is ideal. [NPWS 1999; Goldingay & Kavanagh 1991]

- Critical elements of habitat include sap-site trees, wintering flowering eucalypts, mature trees suitable for den sites and a mosaic of different forest types. [Tanton 1994 in NPWS 1999]

3.3 Conservation Status

Table 1: Summary of conservation status of the Yellow-bellied Glider

Legislative or scientific list	Taxon	Status
NSW TSC Act	*P. australis*	Vulnerable
South Australian *National Parks and Wildlife Act* 1972	*P. australis*	Endangered
Qld *Nature Conservation (Wildlife) Regulation* 1994	*P. a. reginae* (northern subspecies)	Vulnerable
Commonwealth EPBC Act	*P. australis* unnamed subsp. (Wet Tropics)	Vulnerable
Action Plan for Australian Marsupials and Monotremes (Maxwell *et al*. 1996)	*P. a. australis* (S subspecies)	Lower Risk (near threatened)
	P. australis unnamed subsp. (N subspecies)	Vulnerable
2000 IUCN Red List of Threatened Species (Hilton-Taylor 2000)	*P. australis*	Lower Risk (near threatened)
	P. a. australis	Lower Risk (near threatened)

Note:
EPBC Act – Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999
IUCN – International Union for the Conservation of Nature and Natural Resources

[NPWS 2003]

3.4 Diet in the Wild

- As an exudate-feeding mammal, the diet consists primarily of phloem sap from eucalypts as well as nectar, pollen, manna and insect exudates. [Henry & Craig 1984, p331] In NSW, the sap tree species which they select are widely varied. [see Appendix 2]

- Pollen and insects are an important protein source for all members of the Petauridae. A high carbohydrate-to-nitrogen ratio in their diet provides additional energy for activity and territorial defence but has limited reproductive potential. [Macdonald 2001, p835]

- Foraging occurs within a wide range of canopy heights and a very high proportion of nocturnal activity [90%] is dedicated to foraging. [NPWS 1999]

3.5 Longevity

3.5.1 In the Wild

- Individuals live for at least 6 years. [Goldingay & Kavanagh 1991]

3.5.2 In Captivity

- Individuals have been known to survive in captivity for up to 10 years. [Bellchambers 2004]

- The longest longevity record for the species in captivity is for over 14 years at Healesville Sanctuary, Victoria in 1996. [Slater 1997]

3.5.3 Techniques Used to Determine Age in Adults

- The under part fur on the belly ranges from whitish through yellow to orange with increased age. [NPWS 2003]

- In a study by Henry & Craig [1984], the precise aging of captured gliders was not possible, but gliders were classified as subadults or adults according to weight, body size and social status determined by subsequent observation.

- Other aging techniques include the wear of incisors and evidence of lactation in females. [Slater 1997] Non-active scent glands in males and shallow pouches with small teats in females indicate lack of sexual maturity. [Goldingay 1992].

4 Housing Requirements

4.1 Exhibit/Enclosure Design

- Depends on type of captive holding facility. If the Yellow-bellied Glider is held at a conservation zoo, public viewing is at night as animal is nocturnal. In this instance a night enclosure is required. If held at a standard zoo or wildlife park, a nocturnal house enclosure is needed for public viewing during the day. [Phipps]

- Airlocks are the most practical and provide the most security when entering and exiting the enclosure as Yellow-bellied Gliders are able to squeeze past the keeper and doorway quickly and successfully. [Tantini, Taronga Zoo]

- The internal exhibit lighting must be covered in a durable mesh as the gliders continually climb upon it. [Tantini, Taronga Zoo]

- Tree trunks and branches or replicas of trees are necessary for the gliders to glide between and should be placed as far away as possible from each other to increase gliding distances. Landing branches are also necessary. [Tantini, Taronga Zoo]

- Hollow logs or nest boxes are required for den sites and should be located near the top of the enclosure. [Bellchambers 2004]

4.2 Holding Area Design

- Holding areas may be smaller than the public display enclosures however they still need to be big enough for the glider to practice natural behaviours.

- Appropriate furnishings such as nest boxes, branches and tree structures are necessary to ensure the glider is comfortable whether the time in holding is short or long term. [Carroll, pers. obs]

- Holding areas at Taronga Zoo include outdoor enclosures as well as indoor enclosures within the nocturnal house. It is necessary to have holding areas in the nocturnal house for the resident gliders so they can continue living in the reverse-cycle lighting. This is especially important for short-term holding periods.

- At Taronga Zoo the approximate size of the holding areas are 3m x 2m x 2.5m which includes an airlock if needed.

4.3 Spatial Requirements

- Recommended enclosure/cage sizes for static displays of the Yellow-bellied and Greater Gliders:
  Min floor area 20sqm
  Max no of animals 1
  Min height 3m
  Increased floor area for each additional animal 10sqm
  [DPI]

4.4 Position of Enclosures

- Nocturnal houses are designed fully enclosed with the main reason being they are on reverse cycle lighting. Therefore, the position of the enclosure is not limited. [Carroll, pers. obs]

- Ideally outdoor exhibits should be partially enclosed and should not be positioned in direct sunlight.

4.5 Weather Protection

- Outdoor enclosures require a partly covered area for shelter from weather extremities as well as nest boxes for added protection and comfort. [Carroll, pers. obs]

4.6 Temperature Requirements

- Yellow-bellied Gliders adapt to most eastern Australian temperature ranges however heat lamps may be used during the colder winter months.

- The temperature within the nocturnal house is not electronically controlled, however there is a ventilation system to ensure clean air is continually provided. [Carroll, pers. com]

4.7 Substrate

- Wood chips, pine bark and/or leaf litter are ideal floor coverings as waste blends in during the day when visitors are present. [Tantini, Taronga Zoo]

4.8 Nestboxes and/or Bedding Material

- Dimensions of nest-boxes are a combination of those required for the Greater Glider and the Common Ringtail Possum:
  Position in enclosure – min 4m or as high as possible in the enclosure
  Height – 43cm
  Floor – 20x24cm
  Entrance – 6-8cm
  Depth below entrance – 30cm
  [Walraven 1990, p41]; [Uni.Of Ballarat]

- Nest-boxes with hinged lids make it easier to clean and also to catch the glider for examination.

- Hollow logs, closed at one end with a piece of wood or tin, may also be used by gliders for sleeping. [Walraven 1990, p32]

- Peat moss is an ideal base for bedding material and gliders will add leaves and bark to the nest for extra comfort.

4.9 Enclosure Furnishings

- Aerial runways [eg. limbs, branches and vertical logs] providing a great variety of possible aerial pathways near the top of the enclosure are important and necessary components in any enclosure. [Bellchambers 2004]

- Nest boxes should be elevated high in the enclosure and should not be secured to the walls. [Tantini, Taronga Zoo]

- Suitable hiding holes/places are hanging plant holders lined with pieces of peat moss. [Tantini, Taronga Zoo]

- Stainless steel food and water containers should be spread out around the enclosure and are best situated attached to the tree structures.
  [Tantini, Taronga Zoo]

5 General Husbandry

5.1 Hygiene and Cleaning

- Excrement and other animal waste, leftover food, unwholesome food and water, bones, fur, feathers, dead animals and introduced rubbish and foreign objects must be removed daily. [EAPA]

- Daily spot checks for faeces, left over food or any other waste products is essential in maintaining a hygienic environment. Wood chips or pine bark is an ideal floor covering as waste blends in during the day when visitors are present. [Tantini, Taronga Zoo]

- **Daily:** a spot check clean is essential to remove wastes by raking and brushing with a dustpan. Stainless steel food holders are washed with general purpose detergent and rinsed. [Tantini, Taronga Zoo]

  Weekly: browse changes are required. As well as the routine spot checks, tasks such as replacing eucalypt branches may be required. [Tantini, Taronga Zoo]

  Monthly: branches and trunks are to be scrubbed and nestboxes washed out with a general purpose detergent. Nestboxes do not need more frequent cleaning as the gliders take time to create ideal sleeping environments. [Tantini, Taronga Zoo]

  Every second month: a major enclosure clean is essential. Pine bark to be completely replaced. Enclosure to be hosed and cleaned with a general purpose detergent. Disinfectants are only to be used in a disease break-out and great care is to be taken as gliders are highly sensitive to strong cleaning products ie.bleach. [Tantini, Taronga Zoo]

5.2 Record Keeping

This involves recording and keeping information on the following:

- Identification numbers of animals
- Health problems
- Veterinary examinations
- Veterinary treatments
- Behavioural problems
- Reproductive stages, condition or behaviour
- Changes in diet
- Movements within and between institutions
- Body mass and measurements
  [Jackson 2002, p235]

5.3 Methods of Identification

- Ear tags and/or microchips are used for identification of the Yellow-bellied Gliders at Taronga Zoo.

- In a research study by Russell [1984], ear notching was found to be more permanent and less irritating to the glider than use of ear tags.

5.4 Routine Data Collection

- Captive data on the Yellow-bellied Glider is limited. Many areas associated with reproduction, growth and development are still unknown. Currently Taronga Zoo has been successful in breeding the species in captivity. Data collection and records is therefore vital for future breeding successes at Taronga Zoo as well as at other captive institutions. [Carroll, pers. com]

6 Feeding Requirements

6.1 Captive Diet

- Gliders require a varied diet consisting of fresh branches, leaves and flowers from eucalypts and other native trees and shrubs. Live foods such as mealworms, crickets and moths are also highly recommended.

- Supplementary foods include various fresh and dried fruits, vegetables and nuts such as apple, pear, fresh sweet corn, carrot, cucumber, sunflower seed, sultanas, banana, rockmelon, watermelon, peanuts and almonds. [The Marsupial Society]

- Taronga Zoo provides a high protein, high energy gruel called **Leadbeaters Mix**:
  - 150g Heinz high protein baby cereal [Available at all leading supermarkets]
  - hard-boiled eggs [shelled]
  - teaspoon Sustagen
  - 900ml honey
  - 900ml warm water

  Mix all ingredients in blender for two minutes to make a palatable and balanced feed. Makes two litres. This mix can be stored in the refrigerator for up to two weeks. [Walraven 1990, p71] & [De la Motte 1996]

  NB. Substitutes for Heinz high protein baby cereal are as follows:-
  Gerber: single grain cereals [rice cereal]
  Farax: high protein rice cereal
  Beech-Nut Stage 1: rice baby cereal
  Earth's Best: Whole Grain Rice Cereal
  Bellamy's Organic baby food: Rice Cereal
  [Smith, Sydney Wildlife] [Available at most leading supermarkets]

  Recommended daily feeding quantities:
  - 30ml Leadbeaters Mix
  - 20g Fruit

  Activity feeds:
  - Mealworms, crickets & grasshoppers
  - Smooth-barked Eucalypt branches and floral browse

  Breeding Diet [Nov – May]
  - 30ml Leadbeaters Mix
  - 10g Fruit
  - 10x Mealworms – [Sat & Sun]
  - 20x Crickets/Grasshoppers – [Mon, Wed & Fri]
  - 1x Fresh Eucalypt branch/Browse flowers – [Mon, Wed & Fri]

    [De la Motte 1996]

- The captive diet used at Fleay's Fauna Sanctuary in Queensland included:
  - Bread and milk
  - Melon jam
  - Honey
  - Gum blossom
  - Slabs of sapwood from preferred Eucalypt trees
  [Bellchambers 2004]
  Whilst this is not a detailed description of the captive diet, it is evident that the sanctuary focused on providing high amounts of carbohydrate. The inclusion of a protein source, such as live invertebrates, will ensure the diet is balanced.

- Clean potable water must at all times be available for the animal to drink. [EAPA]

6.2 Supplements

- Taronga Zoo does not provide any additional supplements for their captive Yellow-bellied Gliders. All nutritional requirements are met by feeding Leadbeaters Mix, fruit and vegetables and activity feeds. [Davies, Taronga Zoo]

6.3 Presentation of Food

- Leadbeaters mix is placed in stainless steel food holders. These are attached to tree structures around the enclosure. Fruit and vegetable chunks may be spiked onto nails which are also dispersed around the enclosure. [Tantini, Taronga Zoo]

- Mealworms, crickets and grasshoppers may be released under leaf litter in boxes as a foraging exercise. [Tantini, Taronga Zoo]

- Gum reservoirs may be included in exhibits by drilling holes into branches and filling them with plant exudates. This type of feeding provides the gliders with a naturally textured substrate and encourages natural foraging behaviours. [Kelly 1993]

- Activity feeds include smearing peanut butter on tree trunks and squirting natural gums from syringes onto enclosure leaves. [Tantini, Taronga Zoo]

- Pieces of native blossoms, such as Grevillia, Banksia and Protea plants, also encourage natural foraging. [Tantini, Taronga Zoo]

7 Handling and Transport

7.1 Timing of Capture and Handling

- Gliders are most easily captured whenever they are sleeping. This is normally during the day as they are nocturnal however, in a nocturnal house environment the lights will dim at approx 8.30am – 10am leading them to believe that nightfall has begun. [Tantini, Taronga Zoo]

7.2 Catching Bags

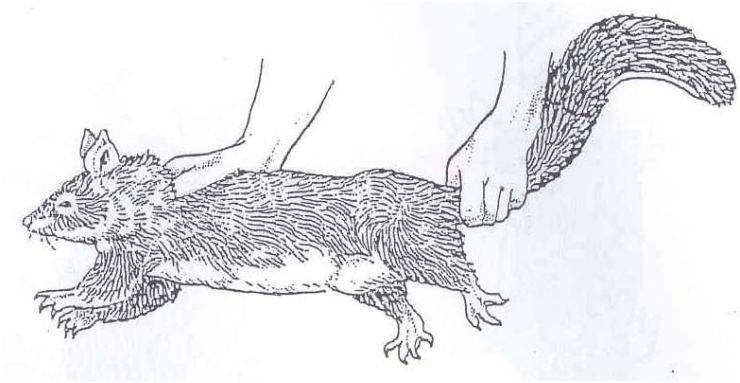
- Calico bags work best as the fabric is string enough to resist tearing from teeth and claws but still allows for ventilation. Softer fabrics, such as cotton, tend to tear too easily. [De Voss, Taronga Zoo]

- Size is generally as big as a standard pillowcase.

7.3 Capture and Restraint Techniques

- Gliders are readily handled by the tail, while the neck and shoulder region is grasped simultaneously. [Walraven 1990, p70]

- Beware – teeth and claws
  Capture – use pillowcase as a glove and scoop inside
  Handling – hold back of head and base of tail firmly



[White, 1997]

7.4 Weighing and Examination

- To weigh, use the capture and restraint techniques demonstrated in the previous notes and place glider in a catching bag. Secure the bag and weigh.

- Ideally, examination should be a two persons job. One person is required to capture and restrain the glider, as above, whilst the other person examines, pouch checks, administers medication or whatever the examination requires. [De Voss, Taronga Zoo]

7.5 Release

- Gliders should be released from a securely tied woven bag infront of their nestbox opening. This enables them to crawl into the safety of the nestbox rather than confusing and overwhelming them in an open area. [Tantini, Taronga Zoo]

7.6 Transport Requirements

- For short-term transporting, hessian sacks or straw-filled boxes are adequate. [Walraven 1990, p70]

- The following is for long-term transporting:

7.6.1 Box Design

- Frame – solid wood, screwed or nailed and glued with a non-toxic glue, metal or non-toxic plastic. [IATA]

- Sides – wood, metal or plastic. The front must consist of a 2/3 solid panel with ventilation openings above a 1/3 wire mesh. [IATA]

- Spacer Bars/Handles – must be provided on three sides of the container. [IATA]

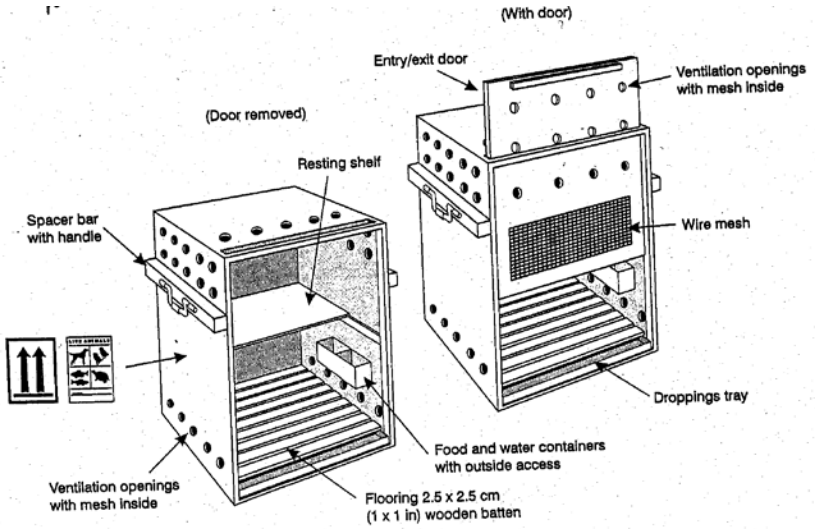
- Floor – a slatted floor must be firmly fixed to the base of the container which must be covered with absorbent material. [IATA]

- Roof – solid but with meshed ventilation openings optional. [IATA]

- Door – must be fastened with tamper proof fastenings. [IATA]

- Ventilation – fine wire mesh must be securely fixed over the door grill and all ventilation openings, these must also be covered with a muslim, or similar material, curtain. [IATA]

- The container must be correctly labelled with
  -'Live Animals' label/tag [green]
  -'This Way Up' label/tag on all four sides of container [IATA]



7.6.2 Furnishings

- A resting shelf of 1/3 the length of the container must be provided in the rear of the box, or

- Branch-like timber must be provided and be firmly attached within the container so that the animal can climb and rest safely. [IATA]

7.6.3 Water and Food

- Animals do not usually require additional feeding or watering during 24 hours following the time of dispatch. If feeding or watering is required due to an unforeseen delay, appropriate food must be provided but care must be taken not to overfeed. [IATA]

- Separate food and water containers, with outside access, must be fixed to the upper part of the door grill in order that the animal cannot sit on them. Water must only be offered when required and must not remain in the container after use but must be siphoned out. [IATA]

7.6.4 Animals per Box

- Animals of the same species and size may be shipped together in the same container *only* if they have previously been housed together. Otherwise, they must be carried completely separately. [IATA]

7.6.5 Timing of Transportation

- Preferably during the day as they are normally inactive at this time which may minimise stress levels. [Tantini, Taronga Zoo]

7.6.6 Release from Box

- Preferably on nightfall when they are becoming active. This allows them start immediately adjusting to the new surroundings. [Tantini, Taronga Zoo]

8 Health Requirements

8.1 Daily Health Checks

- The health of the animal is to be checked daily and any distressed, sick or injured animal must be reported immediately. [EAPA]

- The daily health check includes a Distant Examination [DE] or General Health Assessment [GHA]. This involves using sight, sound and smell to detect any abnormalities. Generally a glider in good condition will be as follows:

Behaviour:	alert, active, foraging, inquisitive
Gait:	even, gliding, climbing
Coat:	smooth, full, no signs of alopecia
Body:	evenly proportioned, no signs of injury
Nose:	moist, no discharges
Eyes:	clear, bright, no discharges
Ears:	intact, no discharges
Anus:	clean, no discharges or unpleasant smells
Feet:	soft, no injuries, nails should be intact, no lumps or lesions

- Daily head counts are necessary to ensure all the gliders are present in the enclosure. This should be recorded.

- Check that the food has been eaten from the previous day and ensure there is no vomit or diarrhoea in the enclosure as well as unfamiliar smells or odours. [Tantini, Taronga Zoo]

- Gliders are known to fight within the group often inflicting serious wounds on each other. Daily checks for fighting injuries are therefore very important.

8.2 Detailed Physical Examination

8.2.1 Chemical Restraint

- Any chemical procedures required for examination including anaesthetics or sedatives are given by a veterinarian.

8.2.2 Physical Examination

- A physical examination involves handling and closely examining the glider to ensure of good health. Key points include:
  - keen reflexes with sharp reaction to stimuli
  - an even weight with no sign of obesity or muscle wastage
  - an even coat free from wounds and parasites
  - no lumps present on or under the skin
  - free limb movement with no sign of stiffness or pain
  - ears, eyes, nose and anus free from unpleasant discharge
  - teeth should be straight and even with no signs of being damaged or overgrown

8.3 Routine Treatments

Daily	- Distant Examinations - Head counts – recorded
Weekly	- Physical examinations of each individual
Monthly/Seasonal	- Individual weighing - recorded - Pouch checks [except during breeding season from Nov-May] [Phipps]
Half Yearly	- Faecal samples taken and tested

- Worming treatments and prophylactic drugs are only given if the faecal sample results indicate the presence of disease and/or parasites. [Davies, Taronga Zoo]

- The gliders' health status is to be recorded daily and veterinary attention is to be sought if any unusual conditions are present. [Tantini, Taronga Zoo]

8.4 Known Health Problems

- Yellow-bellied gliders have been known to fight within their groups causing lesions, bites and loss of toe, tail and ear tips. These wounds usually repair themselves but incompatible animals should be separated. [Tantini, Taronga Zoo]

- Stress can occur in gliders which are exposed to drastic food changes, sudden noises, overcrowding, unsanitary surroundings, isolation and boredom. This leads to behavioural and health problems such as cage pacing, biting and overeating. [Glider Connection 2003]

- Overgrown teeth may result from not regularly supplying eucalypt or native plant branches, or a sufficiently varied diet. [The Sugar Glider]

- ***Hind Leg Paralysis*** [HLP]
  Discovered as a common health problem in captive Sugar Gliders [*Petaurus breviceps*] however, all captive gliders are at risk.
  It is a symptom of nutritional secondary hyperparathyroidism.

  Cause: inadequate calcium absorption due to a poorly balanced diet of low calcium, high phosphate and low vitamin D levels. Causes increased parathyroid hormone which removes calcium from the bones.

  Signs: - paralysis
  - lethargy
  - limping
  - fractured bones
  - tumours
  - weakness
  - loss of use of hind legs or favouring one leg
  - poor gripping ability

  Diagnosis: Clinical signs

  Treatment: Seek veterinary care – usually devise a treatment plan

  Prevention: - Provide a balanced diet
  - Know Calcium: Phosphate [Ca:P] ratios of food and maintain a positive balance [1.2:1]
  [Sugar Glider Basics: Medical Reference]

- ***Stress Syndromes***
  Cause: inadequate captive living conditions which may be one of or a combination of factors. Some of these include; unsuitable enclosure design, inadequate diet, the inability to breed, housing non-compatible animals, capture, transport, loud unfamiliar noises and unfamiliar human contact.

  Signs: Abnormal behaviours are the main indications that a glider is stressed. These may include any of or combinations of the following:
  - failure to eat or drink
  - depression
  - weight loss
  - diarrhoea
  - pacing in enclosure
  - not active

- not sleeping in nest boxes
- biting
- overeating

Treatment: Work out and remove/eliminate the stressor/s. This may involve animal behaviour observations over a period of time to work out what is stressing the glider. Examples of solutions may be enclosure re-structures, housing compatible animals only, revising the diet, animal conditioning and providing suitable breeding conditions.

Prevention: To prevent a glider suffering from stress it is important that the captive keeper completely understands all the requirements of the animal. Some stress preventative measures include:

- providing an adequate diet
- natural surroundings in the enclosure
- environmental enrichment
- developing breeding programs
- practicing good husbandry
- animal conditioning to captive routines including husbandry and medical procedures

- A variety of worms may be found in gliders however tapeworms, fluke and roundworms appear to be common. Gliders and possums do not carry as many worms as macropods. Most gliders carry worms but often this does not cause any health problems. [Stanvic 1992, p40]

8.5 Quarantine Requirements

The following information has been summarised from the Primary Industries & Natural Resources Division, Wildlife Husbandry 2 Resource Manual, 2001.

- Newly received animals should be quarantined to prevent contact with existing animals until their health has been evaluated.

- In general, mammals should be quarantined for a minimum of 30days.

- Factors affecting the length of quarantine include:
  - disease potential
  - incubation periods
  - facilities available
  - source of quarantined animal [commercial, wild, farm, zoo – national/international]

- Quarantine facilities should be physically separate/isolated from the rest of the collection.

- Hygiene procedures and personal hygiene practices are vital to prevent cross-contamination to:
  - other animals in quarantine
  - animals in the collection
  - feral animals
  - humans

9 Behaviour

9.1 Activity

- The Yellow-bellied Glider is nocturnal and during the day it rests in dens in a hollow branch, usually in a living, smooth-barked eucalypt. [Russell 1995]

- It emerges at night and is an active and very mobile climber. It may travel over two kilometres from its den to forage within a wide range of canopy heights. [Russell 1995]

- They spend more than 80% of the time outside their dens feeding. When feeding time is added to other essential foraging behaviours [such as gliding and climbing], approximately 90% of this time is accounted for. This is one of the highest values yet found for a mammal. [University of Wollongong 2000]

- While foraging, they are essentially solitary except when food resources are localised and clumped as at sap-site trees. [Henry & Craig 1984]

- Yellow-bellied Gliders work their way through the upper branches of trees, tearing away decorticating bark and investigating the exposed surface. Frequently they open hanging rolls of dead bark even when hanging by their hind legs. [Henry & Craig 1984]

- Grooming of the tail and lower body is undertaken while hanging head-down from a slender support. [Russell 1995]

- The most distinctive call is a short, high-pitched shriek that subsides into a throaty rattle. This territorial call can be heard at a distance of 400 metres. [Russell 1995] Russell [1984] has constructed an extensive call classification table [see Appendix 1].

9.2 Social Behaviour

- The Yellow-bellied Glider has a large home-range between 30 and 65 hectares [Goldingay & Kavanagh 1991] and usually occurs in densities of 0.05 – 0.14 individuals per hectare in its preferred habitat. [Russell 1995]

- There is a high degree of sociality. In the southern range it is usual for a male to share a den with an adult female and one young. In the northern range a male may associate with two to three adult females and up to three young. [Russell 1995]

- Dominant males scent-mark their group members by head and tail rubbing. They have an active scent exuding gland on their head and tail. [Russell 1984]

- Scent-marking indicates group cohesion by communicating an individual's social status, sex, group membership, and reproductive position. [Macdonald 2001, p838]

- The defence of home ranges from intruders is usually undertaken by the glider of the same sex of the intruder. More simply, males will challenge intruding males whilst females will challenge intruding females.

9.3 Reproductive Behaviour

- Mating generally occurs from August - December in Victoria but throughout the year in Queensland. [Nowak, online]

- Mating can occur while the pair is clinging to the underside of a stout branch. Strahan 1995, p227]

- There are no extensive records of courting behaviour however in a study by Russell [1984], buccal clicks, which are non-vocal soft clicking sounds, were recorded when a male and female were moving about together with the female possibly in oestrous. [See Appendix 1]

9.4 Bathing

- Yellow-bellied Gliders have not been recorded bathing in any type of medium.

- Grooming is predominantly performed individually by using their incisors to comb through the fur. Studies also show that lower rank gliders may groom those of higher status.

9.5 Behavioural Problems

- Fighting amongst the group is a main behavioural problem. Many males will fight to the death if the problem is not dealt with and females have been known to fight viciously also. [The Marsupial Society]

- Becoming overly tame and friendly is an unnatural behaviour. This can become a problem when entering and exiting the enclosure as these gliders will playfully pounce on a keeper when entering and follow the keeper on exiting. [Tantini, Taronga Zoo]

9.6 Signs of Stress

- Abnormal behaviours are the main indications that a glider is stressed. These may include any of or combinations of the following:
  - not eating or drinking
  - pacing at front of enclosure / cage pacing
  - constantly waiting at the entry/exit door
  - not active at night
  - not sleeping in nestboxes
  - biting
  - overeating

  [Tantini, Taronga Zoo]

9.7 Behavioural Enrichment

- Provide activity feeds and novel food items to increase foraging times. Eg. providing live invertebrates. [EATA]

- Placing tree structures far apart with landing branches encourages natural gliding behaviour. Branches should be positioned close to the public viewing window to increase visibility of the glider. [Tantini, Taronga Zoo]

- At the time of complete enclosure cleaning, furnishings are positioned differently in the exhibit. This is a form of environmental and behavioural enrichment as the gliders love to explore the new surroundings. [Tantini, Taronga Zoo]

- In nocturnal house enclosures the lighting is on reverse-cycle. The lights will dim between 8.30am and 10am mimicking nightfall and feeding will take place at this time. This increases the gliders' activity levels to benefit the public's viewing.

- Spiking various foods on tree structures facing the public viewing window is not only a form of behavioural enrichment but increases visibility of the glider for the public.

9.8 Introductions and Removals

- Newly received animals should be quarantined to prevent contact with existing animals until their health has been evaluated. [Primary Industries & Natural Resources 2001]

- Yellow-bellied Gliders live in family groups comprised of a dominant male, female/s and young offspring. Introducing a new glider to an existing colony, especially another male, is risky as dominant gliders will fight intruders to the death.

- Removal of a glider that is to be returned to the group should be as minimal as possible to avoid a change in the groups' hierarchy and aggressive encounters upon returning.

9.9 Intraspecific Compatibility

- Yellow-bellied gliders are best kept in pairs as they are highly social animals. The young have a long period of association with the parents and the male aids in the rearing of the sub adult offspring. [Henry & Craig 1984, p340]

- Gliders have very strong social bonds and members of a colony know each other intimately by their scent. Males mark their territory by scenting from head glands and both sexes regularly mark [using urine] practically everything in their enclosure. [The Marsupial Society]

- Fighting will sometimes occur within a group of gliders. Some animals will prove themselves incompatible and will require permanent separation. [The Sugar Glider]

- Avoid housing separate colonies of gliders in adjacent cages where animals can bite each other through the dividing wire. [The Sugar Glider]

9.10 Interspecific Compatibility

- Yellow-bellied Gliders share well with a range of ground dwelling animals including Potoroos and Brush-Tailed Bettongs. It is not suitable to enclose them with another arboreal species as overcrowding in the tree structures will occur. [Tantini, Taronga Zoo]

9.11 Suitability to Captivity

- There are aspects of the Yellow-bellied Glider which makes it rather suited to a captive life and some which makes captive requirements more difficult.
  Suitable aspects are as follows:
  - Classified as non-hazardous therefore protocols are less complicated compared to that of dangerous animals.
  - Stress is main disease of concern but can be easily prevented with good husbandry practices and enrichment.
  - They are an arboreal species and may be housed with certain ground dwelling species. This makes the exhibit appear more lively and reduces the number of exhibits.

  Less suitable aspects are as follows:
  - Being a nocturnal species a nocturnal house is required for public viewing at captive institutions open during the day.
  - Since 90% of the gliders nocturnal activity is foraging, the keepers are required

to provide ample foraging activities which can take up a large portion of time.
- Breeding potential is low and is thought to be linked to reliability and availability of food resources. Therefore it is difficult to provide the right balance of certain food types to trigger breeding.
- Fighting often occurs between incompatible gliders and requires the separation of the animals which can take up valuable room in other enclosures.

10 Breeding

10.1 Mating System

- In Victoria and the NSW southern tablelands, the Yellow-bellied Gliders' mating system is monogamous comprising of a single breeding pair, with or without offspring. [Henry & Craig 1984]

- Mating systems in north Queensland and the south coast of NSW alternate between monogamy and polygyny and groups may contain up to six individuals. [Russell 1984; Goldingay 1992 in NPWS 2003]

- The differences in family group dynamics and breeding systems are thought to be linked to reliability and availability of food resources. [Goldingay 1992 in NPWS 2003]

10.2 Ease of Breeding

- The Yellow-bellied Glider has low breeding potential. A high sap and low insect diet would imply a restrictive protein intake and may explain the species observed low fecundity. [Bellchambers 2004]

- The availability and abundance of certain food resources appears to coincide with mating, lactating and weaning processes.

- Recently Taronga Zoo has successfully bred a single young for the first time. Previous breeding attempts have been unsuccessful. Australian Mammal keeper Paul Davies believes the success comes from not disturbing the gliders such as not performing regular pouch checks. The only interference from the keepers was increasing feeding amounts prior to the breeding season.

10.3 Reproductive Condition

10.3.1 Females

- *Juvenile, non-breeding*: pouch clean and dry, and teats small.
- *Adult, non-breeding*: pouch dry and dirty.
- *Oestrous*: behaviour patterns or cornified epithelial cells.
- *Pregnant*: pouch pink in colour and glandular in appearance.
- *Post-partum*: pouch young present.
- *Lactating*: young visible on parent's back or in the nest.
- *Post-breeding*: teats expressing only clear liquid and/or regressing.

10.3.2 Males

- Females will only mate with the dominant male of their group. Only the dominant male has an active scent exuding gland on his head and tail which he rubs onto his group members. This is a signifier of the reproducing male.

10.4 Techniques Used to Control Breeding

- Sex separation
- Pouch checks
- Removal of pouch young
  [Phipps]

10.5 Occurrence of Hybrids

- Unknown

10.6 Timing of Breeding

- The time of breeding varies depending on factors such as location and certain food availability. In general, a single young is born between November and May in the southern range species and from May to September in the northern species, although some births have been recorded throughout the year in the north.
  [Russell 1995; Cronin 1991]

10.7 Age at First Breeding and Last Breeding

- Sexual maturity is 18 -24 months however, age at last breeding is unknown.

10.8 Ability to Breed Every Year

- The Yellow-bellied Glider has low breeding potential. A single young is usually produced each year, but breeding may sometimes occur in alternate years.
  [Goldingay & Kavanagh 1990 in NPWS 2003]

10.9 Ability to Breed More than Once Per Year

- A single young is usually produced each year, however a study conducted by Russell [1984] showed that if the female loses a young, she is able to fall pregnant again within that year. The study also found that females are able to abort their young as in the case of a dominance change in males. Therefore most females will usually only rear the dominant males' young.

10.10 Nesting, Hollow or Other Requirements

- Henry & Craig [1984] found nest sites of the Yellow-bellied Glider were primarily in living eucalypts.

- Gliders of both sexes nip leafy twigs from the crown of the nest site tree and transport them into the den, carrying the leaves in a twist of their tail. [Henry & Craig 1984]

- The entrance of the nest site is typically large enough to permit the entry of the occupant, but small enough to preclude predators and other species that may attempt to usurp the use of the den. [Macdonald 2001, p837]

10.11 Breeding Diet

- Taronga Zoo provides a breeding diet for the Yellow-bellied Glider between November and May. This includes:

  30ml Leadbeaters Mix
  10g Fruit
  10x Mealworms – [Sat & Sun]
  20x Crickets/Grasshoppers – [Mon, Wed & Fri]
  1x Fresh Eucalypt branch/Browse flowers – [Mon, Wed & Fri]
  [De la Motte 1996]

  In comparison to the usual diet, the breeding diet is higher in protein with a decreased amount of fruit provided. The increased protein is vital for the growth and development of the young.

10.12 Oestrous Cycle and Gestation Period

- The gestation period for the Yellow-bellied Glider is unknown, however in the Petauridae family the gestation period ranges between 12–50 days with all young weighing less than 1g [0.035oz] at birth. [Macdonald 2001, p834]

- Pouch life is 90-100 days after which the young is left in the nest while the mother forages. After leaving the pouch the young is suckled for a further 40-60 days. [Russell 1995]

10.13 Litter Size

- A single young is almost always produced. Despite the female pouch having two compartments each with a teat, there have only been two records of twins in the species. [Craig 1986; Goldingay *et al* 2001 in NPWS 2003]

10.14 Age at Weaning

- Weaning is between 180-240days [Johnson 1994]. At this time the young begin to leave the nest and start foraging independently. When first venturing abroad, the young make very short glides, travelling chiefly by clambering and jumping between branches. [Russell 1984]

- The male parent aids in the rearing of the subadult offspring, particularly when the female has another pouch young. This involves socialisation with the young, babysitting and leading the young to foraging sites. [Henry & Craig 1984]

10.15 Age of Removal from Parents

- The young have a long period of association with the parents, during which they do not appear to be sexually active. [Henry & Craig 1984]

- A study by Henry & Craig [1984] showed that dispersal from the parent group primarily occurred when subadults were 18 to 24 months old, by which time they had attained adult body weight.

10.16 Growth and Development

Eyes open: 100 days
Final pouch exit: 100 days-left in nest whilst female forages for food
Age at weaning: 180-240 days
Sexually mature: 18-24 months
Fully grown measurements:

Head and Body Length
270 – 300mm
Tail Length
420 – 480mm
Weight
450 – 700g

11 Artificial Rearing of Yellow-Bellied Gliders

11.1 Housing

- Yellow-bellied Gliders are marsupials therefore it is important to mimic a pouch environment when artificially rearing them.

- A pouch substitute should be provided. It should be a snug fit around the joey and be flexible. [Stanvic 1992, p25]

- A woollen beanie is ideal as it flexible and can stretch. However, wool constantly snags onto the glider's claws and is difficult to clean therefore it is recommended to line the inside with a cotton handkerchief or similar material. This liner can also be easily cleaned and replaced between meals. [Stanvic 1992, p25]

- The woollen pouch can be placed in a pet pack or a type of secure basket to protect the joey and also make transporting easy.

- For furred joeys, suitable housing includes a carry cage with bars close together or small wire and shade cloth. A plastic picnic box is ideal. It should have newspaper on the floor covered in native leaf litter [taken from an area where dogs and cats have not been in contact with it]. Native branches should be fitted for climbing. The glider's pouch should be secured to the side of the cage so it is able to climb in and out. [Wood 2005, p174]

- When the glider is well furred, it can be placed in its pouch, in its glider box, in an outside aviary. Assure that it is escape proof by totally lining it with shade cloth. Preferable dimensions are 1.8 x 5 x 3metres however these are a minimum, the bigger the better. The glider should slowly acclimatise to the outdoor enclosure and should be offered native branches of varying thicknesses for climbing and chewing on. Native leaf litter, a shallow bowl of water and a nestbox should also be provided. [Wood 2005, p175]

11.2 Temperature Requirements

- The temperature inside a mother glider's pouch is approximately 38'C when the joey is in the pouch and about 35'C when the joey is out of the pouch. She also often licks the joey and the pouch lining which increases the humidity. [Stanvic 1992, p25]

- Temperature recommendations during artificial rearing are as follows:
  - Furless joeys 30-35'C
  - Furred joeys 32'C
  - Weaned young 28'C

- The relative humidity should be high enough to ensure the joey's skin does not dry out. [Stanvic 1992, p25]

- To regulate the temperature, items such as hot water bottles, heat pads or humidity cribs are the most recommended. [Stanvic 1992, p25]

- Yellow-Bellied Gliders' need a heat source until they are about 100 days old and around 60 to 70 grams. The heat source may be removed when they are tolerating 5 feeds per day, thermoregulating and have a good covering of fur. Start by first turning off the heat source during the day then gradually at night. [Wood 2005, p173]

11.3 Diet and Feeding Routine

- Hand rearing formulas for gliders are milk substitutes. The most commonly used products are Wombaroo, Di-Vetelact, Digestelact and Biolac[see Appendix 3]. These are recommended as they are the closest formulas to resembling the mother glider's milk. They can be purchased from leading pet stores and pet suppliers.

- The makers of these products provide quantities of the formula as well as providing information via tables and charts regarding weight, measurement, growth and feeding amounts. [Stanvic 1992, p26]

- Glider milk changes in composition after the young becomes furred. It increases in protein as the joey matures. It is important to determine an approximate age of the joey and to weigh the joey to formulate the correct amount of food and frequency of feeding. Following the charts on the product boxes is highly recommended. [Stanvic 1992, p28]

- Method of delivering food to the joey will depend on the joey's age. Stanvic recommends using a glass syringe with a marsupial teat on the end as it gives the user better control of the flow of the milk formula. Stanvic states that she never uses bottle on baby gliders as there is no way of controlling the milk flow. [Stanvic 1992, p28].

- Stanvic recommends wrapping the joey firmly in a handkerchief whilst feeding and placing the teat in the side of the joey's mouth. It can sometimes take time for the joey to adapt to feeding from the teat. [Stanvic 1992, p28]

- Joey's should never be fed in a laying position. They should always be upright. Also do not feed a chilled joey. [Stanvic 1992, p28]

- Fully emerged furred young need to be taught to lap from a small dish and should be offered native browse, gum tips and fruit as much as possible. [Stanvic 1992, p32]

- Washing the joey's face with a moist cotton ball or tissue before a feed will often stimulate them. After feeding the raiser must toilet the glider by gently rubbing the cloaca with a moist tissue or cotton ball. [Stanvic 1992, p29] Urine should be colourless and odourless. [Wood 2005, p171]

- If the joey does not eat it may be:
    - cold: therefore warm the joey and try again later
    - thirsty: ie. needing water/Lectade not milk
    - in pain: so examine the joey carefully
      [Wood 2005, p172]

- Unfurred joeys should be able to cope with 4 hourly feeds. When the joey is stable and gaining weight [at least 1 or 2gms] and its faeces are solid, a night feed may be missed and 3 days later another feed may be ceased. [Wood 2005, p172]

- Weaning of the Yellow-Bellied Glider is as follows:
  - at 150g 3 feeds/day.
  - at 200g 2 feeds/day
  - at 250g 1 feed/day
  - fully weaned at 300g [approx. 180-240 days old]
  [Wood 2005, p 176]

- A small amount of lorikeet/honey-eater mix [no more than 20mls], fruit pieces [spiked in enclosure] as well as mealworms should be provided during and after weaning. [Wood 2005, p176]

- Ideal native browse to provide in the aviary includes:
  - Eucalyptus [gum]
  - Acacia [wattle]
  - Callistemon [bottlebrush]
  - Grevillea
  - Leptospermum [tea tree]
  - Melaleuca [paper bark]
  - Pittosporum
  - Brush Box
  - Lilly Pilly
  - Banksia

  The browse will attract insects. The new growth also incubates insect larvae and pupae which the gliders love to chew on. [Wood 2005, p175-176]

11.4 Specific Requirements

- When fostering a pouch aged joey the recommended procedure is as follows:
  - Weigh and measure the tail
  - Check for dehydration by pinching the skin at the back of the neck. If the skin fails to immediately return to normal and stays wrinkled the joey should be given Lectade instead of milk formula for 24 - 48 hours. [Stanvic 1992, p27]
  - Get a heat source ready but do not place the joey directly on it.
  - Once the joey is hydrated, stress is less of a problem. Make sure the joey is warm and then begin feeding the milk formula. [Stanvic 1992, p27-28]

- Whilst the joey is still naked, try to feed, toilet and clean it inside the beanie as this will minimise stress. [Stanvic 1992, p26]

- If a naked joey's skin begins to dry out or peel, 'Sorbolene' cream may be applied to the skin to rehydrate it. [Stanvic 1992, p29]

- Brushing furred joeys' mimics the mother's natural instinct to continually groom and lick her young. It is important the joey feels secure and clean which helps

prevent stress related diseases. [Stanvic 1992, p29]

- If the fur is not growing properly the glider may have internal parasites and need treatment. Another reason may be the glider has a vitamin deficiency. Pentavite drops added to the milk formula [2 drops per 50ml] may assist this. [Wood 2005, p176]

- Use the same washing liquid/powder all the time. Different smells will cause stress. [Wood 2005, p168]

- Hang washed pouches and linen out in the sun whenever possible as sunshine kills bacteria and fungal spores. [Wood 2005, p168]

11.5 Data Recording

- The information recorded during the hand-rearing process is very important as it:
  - provides background information, such as food consumption, that will assist a veterinarian reach a diagnosis if the animal becomes sick or fails to grow or gain weight
  - allows comparison with established growth curves to assess development or
  - facilitates the creation of standard growth curves for those species where they are not already available [Jackson 2002, p240]

- The following information should be recorded on a daily basis:
  - Date
  - Time when the information was recorded
  - Body mass to the nearest 1g, if possible
  - General activity and demeanour
  - Characteristics and frequency of defecation and urination
  - Amount [g or ml] and types of food offered
  - Food consumption [g or ml] at each feed
  - Veterinary examination and results [Jackson 2002, p240]

11.6 Identification Methods

- Information on the growth and development of pouch young is limited and there has been no specific data recorded on distinct physical characteristics of growing joeys at different ages. Refer to previous 10.16 Growth and Development for the limited information which has been provided.

11.7 Hygiene

- Hygiene is very important. The raiser should wash their hands before and after feeding and cleaning time. All feeding equipment must be sterilised in a mild disinfectant and beanies, liners, towels etc. should be soaked in a sterilising

solution such as Napisan. [Stanvic 1992, p31]

- Hygiene of the joey is also important. It is necessary to clean any milk formula left on the skin or fur to prevent it from ingesting bacteria when it grooms itself.

- Take out left over fruit and lorikeet mix from the enclosure during the day as it attracts ants and fruit flies and can breed bacteria. Inspect each glider for sticky fur daily and clean any spots with warm water. [Woods 2005, p176]

11.8 Behavioural Considerations

- Yellow-bellied Gliders are best raised with other young as they naturally occur in family groups

- When introducing gliders to each other for the first time, it can be highly stressful for them, especially if you put them into the same box straight away. Leave them in separate cages next to each other for approximately 3 nights to allow them to acclimatise to their new situation. [Wood 2005, p178]

- Possums and gliders unlike parrots do not human-bond. They see the raiser as a food supply and security if they need it. However, if the glider is to be released back to the wild, human contact should be kept to a minimum to ensure they do not lose their FFF [Fright, Flight, Fight] distances from humans and pets. [Stanvic 1992, p29]

11.9 Use of Foster Species

- Unknown. No records available.

11.10 Weaning

- Weaning the Yellow-Bellied Glider is as follows:
  - at 150g 3 feeds/day.
  - at 200g 2 feeds/day
  - at 250g 1 feed/day
  - fully weaned at 300g [approx. 180-240 days old]

  [Wood 2005, p 176]

- A small amount of lorikeet/honey-eater mix [no more than 20mls], fruit pieces [spiked in enclosure] as well as mealworms should be provided during and after weaning. [Wood 2005, p176] They should be offered native browse [types listed in 11.3], gum tips and invertebrates. The diet should mimic the glider's natural diet as much as possible. [Stanvic 1992, p32]

11.11 Rehabilitation and Release Procedures

- Animals that are to be returned to the wild should not be tamed at any time during rehabilitation as this will be detrimental when they return to their natural habitat. [Walraven, p201]

- Timing of the release must be managed to avoid releasing during breeding season as well as in some seasons such as the middle of winter when food supply is more scarce. [Walraven, p202]

- Yellow-Bellied Gliders should be released 3 or more weeks after being weaned and given time to build up their muscle tone and attain a good, healthy weight. An ideal release weight is 350gms at about 8-10months old. [Wood 2005, p179]

- Since Yellow-bellied Gliders are nocturnal, they should be released just after dark to give them the maximum active hours possible to settle and find somewhere safe to rest. [Walraven, p202]

- The release site should satisfy the following:
  - correct habitat for the glider
  - be within the species known distribution
  - all the biological, nutritional and behavioural needs of the animal to be released
  - be free of known factors likely to prevent survival [Walraven, p203]

- The glider to be released should:
  - show normal behaviour for the species towards humans [ie. fear, aggression]
  - have no permanent physical impairment
  - be of appropriate weight fro the age and sex of the species
  - be acclimatised to the local temperatures of the release site
  - be able to recognise, manipulate and process its natural diet [Walraven, p203]

- There are 3 types of releases:
  1. **Soft Release**: An animal and its buddies are housed in aviary at the release site for 2-3weeks. The door of the aviary is then opened to allow the gliders to explore their new surroundings for a week whilst still having access to their den. The den is then affixed high in a tree and the aviary closed. A little supplementary lorikeet mix may be left for a few days. [Wood 2005, p183]
  2. **Hard Release:** An animal and its buddies are taken to a release site and put into their den which has been affixed in foliage high in a tree. Some supplementary food is left. A follow up is unable to be undertaken.
  3. **Self Release**: An animal or animals escape from care at any stage during the rehabilitation.

- In the case of the Yellow-Bellied Glider a soft release is most preferable, however at times there may be no soft release facilities anywhere in the suitable range so it will have to be hard released. This is highly unsatisfying and the success rate is not good. [Wood 2005, p185]

Acknowledgements

Graeme Phipps, Wildlife Husbandry Lecturer & Tutor, Richmond College NSW.

Michelle Tantini, Australian Mammal Keeper, Taronga Zoo Sydney.

Nick De Voss, Australian Mammal Keeper, Taronga Zoo Sydney.

Paul Davies, Australian Mammal Keeper, Taronga Zoo, Sydney.

Elissa Smith, Sydney Wildlife Carer, Sydney.

13 References

Bellchambers K 2004, *Yellow-bellied Glider*, The Marsupial Society of Australia, available at http://www.marsupialsociety.org/yellow_bellied_%20glider.html. Date accessed 18/05/2004.

Cronin L 1991, *Key Guide to Australian Mammals*, Reed International Books Australia Pty Ltd, Victoria.

De la Motte K 1996, *Nocturnal House Diets.* Taronga Zoo Australia Division.

Department of Primary Industries [DPI], *Code of Practice for the Public Display of Exhibition of Animals*. Available at http://www.dpi.vic.gov.au/dpi/ Date accessed 31/05/2004.

Glider Connection 2003, *Sugar Gliders*. Available at http://www.gliderconnection.com/PocketPetAppeal.html. Date accessed 05/06/2004.

Goldingay RL 1992, Socioecology of the Yellow-bellied Glider [*Petaurus australis*] in a Coastal Forest. In *Australian Journal of Zoology* 40:267-78.

Goldingay RL & Kavanagh RP 1991. 'The Yellow-bellied Glider: a review of its ecology, and management considerations' in D Lunney [ed] *Conservation of Australia's Forest Fauna.* Royal Zoological Society of NSW, Mosman.

Henry S & Craig S 1984, 'Diet, Ranging Behaviour and Social Organization of the Yellow-bellied Glider [*Petaurus australis* Shaw] in Victoria', in Smith A & Hume I [eds], *Possums and Gliders*, Surrey Beatty & Sons Pty Limited, Norton NSW.

International Air Transport Association [IATA] 1998, *Live Animals Regulations 25th Edition.* IATA Resolution 620 Attachment "A". Montreal, Geneva.

Jackson, S.M. (2002) *Standardizing captive-management manuals: guidelines for terrestrial vertebrates* revised, in International Zoo Yearbook (2003) 38: 229-243, The Zoological Society of London, London.

Johnson D 1994, *Gliders and Their Basic Care*. Available at http://www.wires.org.au/docs/scangld1.doc. Date accessed 16/08/2004.

Kelly K 1993, *Environmental Enrichment for Captive Wildlife Through the Simulation of Gum Feeding.* Animal Welfare Information Center Newsletter. Available at http://www.nal.usda.gov/awic/pubs/primates/4n3kelly.htm. Date accessed 07/09/2004.

Macdonald D [ed] 2001, *The New Encyclopedia of Mammals*, Oxford University Press, Oxford UK.

Museum Victoria 2002, Victorian Mammal Images. Available at http://www.museum.vic.gov.au/bioinformatics/mammals/images/austffoot.htm. Date accessed 02/09/2004.

Museum Victoria 2002, Victorian Mammal Images. Available at http://www.museum.vic.gov.au/bioinformatics/mammals/images/austside.htm. Date accessed 02/09/2004.

The Marsupial Society of Australia, *Keeping and Breeding Marsupials in Captivity*. Available at http://www.marsupialsociety.org/sugar_glider.html. Date accessed 31/05/2004.

Nowak R M [online], 'Lesser Gliding Possums' in *Walker: Mammals of the World Online*. Available at http://www.press.jhu.edu/books/walkers_mammals_of_the_world/marsupialia.petauridae.petaurus.html. Date accessed 27/07/2004.

NSW Agriculture, *Exhibited Animals Protection Act [EAPA]*. Available at http://agric.nsw.gov.au. Date accessed 31/05/2004.

NSW National Parks and Wildlife Service 2003, *Recovery Plan for the Yellow-bellied Glider [Petaurus australis]*. Available at http://www.nationalparks.nsw.gov.au/PDFs/recoveryplan_final_yellowbellied_glider.pdf. Date accessed 18/05/2004.

NSW National Parks & Wildlife Service 1999, *Yellow-bellied Glider*. Available at http://www.nationalparks.nsw.gov.au/PDFs/tsprofile_yellowbellied_glider.pdf. Date accessed 18/05/2004.

Primary Industries & Natural Resources 2001, *Introduction to Wildlife Husbandry 2*, TAFE NSW Resource Manual. Orange, NSW.

Russell R 1995, 'Yellow-bellied Glider: *Petaurus australis'* in R Strahan [ed], *The Mammals of Australia*, New Holland Publishers, Frenchs Forest, Sydney.

Russell R 1984, 'Social Behaviour of the Yellow-bellied Glider, *Petaurus australis reginae* in North Queensland,' in Smith A & Hume I [eds], *Possums and Gliders*, Surrey Beatty & Sons Pty Limited, Norton NSW.

Slater G 1997, Longevity of Yellow-bellied Glider *Petaurus australis*. In *Victorian Naturalist* 114[5]: 241.

Stanvic S 1992, Possums: Rescue, Rearing, Rehabilitation, Release. Manual reference.

Strahan R 1995, *A Photographic Guide to Mammals of Australia*, New Holland

Publishers, Frenchs Forest, Australia.

The Sugar Glider. Available at http://members.iweb.net.au/~msa/sugar_glider.htm. Date accessed 05/06/2004.

Sugar Glider Basics: Medical Reference. Available at http://www.glideruniversity.org/basics/referencehtoz.htm#hlp. Date accessed 05/06/2004.

University of Ballarat, *Nestbox Dimensions – Mammals.* Available at, http://www.ballarat.edu.au/ard/sci-eng/hotspot/nestboxes/buildyourown/mammals.pdf. Date accessed 18/05/2004.

University of Wollongong 2000, Biology Thesis: Abstract. Available at http://www.uow.edu.au/research/current/ThesisWritingResources/Abstracts/Biology/Abstract.pdf. Date accessed 16/08/2004.

Walraven E 1990, *Taronga Zoo's Guide to the Care of Urban Wildlife*, Allen & Unwin, Sydney.

Walraven E, *Rehabilitation and Reintroduction of Native Fauna.* Veterinary Post0Graduate Course, Sydney University, Sydney.

White S 1997, *Caring for Wildlife,* Australian Geographic Pty Limited, Australia.

Wood L 2005 in Rescue and Rehabilitation and Release of Possums & Gliders. WIRES Training Manual. Pgs 143-192.

Yellow-bellied Glider [pic] 1983 in *The Australian Museum Complete Book of Australian Mammal,* Strahan R [ed], Angus & Robertson Publishers, Australia, pg137.

14 Bibliography

Animal Care Introductory Practices, Resource Manual. Compiled by Barrell T & Sutton L, Richmond College TAFE, NSW.

Craig SA 1986, A Record of Twins in the Yellow-bellied Glider, [*Petaurus australis* Shaw] [Marsupialia: Petauridae] with Notes on the Litter Size and Reproductive Strategy of the Species. In *Victorian Naturalist* 103: 72-75.

CSIRO Wildlife Research, *Feeding Behaviour of the Yellow-Bellied Glider [Petaurus australis] at the Western Edge of its Range.* Available at http://www.publish.csiro.au/nid/144/paper/WR98021.htm. Date accessed 16/08/2004.

Jackson, S.M. (2002) *Standardizing captive-management manuals: guidelines for terrestrial vertebrates* revised, in International Zoo Yearbook (2003) 38: 229-243, The Zoological Society of London, London.

Lindenmayer D 2002, *Gliders of Australia: A Natural History*, University of New South Wales Press Ltd, Sydney NSW.

Menkhorst P & Knight F 2001, *A Field Guide to the Mammals of Australia*, Oxford University Press, Melbourne.

Smith A & Winter J 1997, *A Key and Field Guide to the Possums Gliders and Koalas*, Surrey Beatty & Sons, Norton NSW.

Triggs B 1996, *Tracks, Scats and Other Traces: A Field Guide to Australian Mammals*. Oxford University Press, Melbourne.

Williams R 1990, 'Possums and Gliders' in Hand S[ed], *Care and Handling of Australian Native Animals: Emergency Care and Captive Management.* Surrey Beatty & Sons PTY Limited, NSW.

WIRES, *Yellow Bellied Glider*. Available at http://www.wires.org.au/animals/yllwgldr.htm. Date accessed 27/07/2004.

15 Glossary

Acclimatise	to adapt to a new climate or environment.
Aerial	existing in the air.
Alopecia	loss of hair due to stress or disease.
Arboreal	living in trees.
Browse	leaves and twigs of shrubs and trees.
Canopy	the leafy branches of forest trees, forming a dense cover for the vegetation beneath, as in a rainforest.
Cloaca	a single opening containing the termination of the digestive, urinary and reproductive tracts in birds, reptiles, many fish and some mammals.
Dehydration	loss of water from the bodily tissues.
Den	a secluded place, as a cave, serving as the habitat for a wild animal.
Detergent	a cleaning agent.
Disinfectant	a strong chemical that removes or disables micro-organisms.
Distant exam	the senses sight, smell and sound are used to examine an animal.
Dwell	to live in a place.
Ear notching	cutting a V-shape in the edge of the ear for identification purposes.
Ear tags	a strip or label attached to the ear for identification purposes.
Enrichment	to improve in quality by adding to.
Excrement	waste matter discharged from the bowels.
Exudate	discharged matter from pores or incisions.
Fecundity	fertility.
Fingerling	a young fish.

Forage	to search for food.
Gestation	the act or period of carrying young in the womb; pregnancy.
Gruel	a thin porridge mixed with water or milk.
Habitat	an area providing the physical and biological needs of a species.
Incompatible	not able to exist together in harmony.
Incisors	any of the front cutting teeth at the front of the mouth.
Juvenile	of a young age; not fully mature.
Lactating	the secretion of milk.
Manna	sugary exudate of leaves and branches.
Mesh	a knitted, woven, or knotted fabric, with open spaces between the threads.
Monogamous	mating of a single male with a single female involving no other individuals of either sex.
Nocturnal	active during the night.
Oestrous	the period of ovulation in mammals.
Palatable	a pleasant, acceptable taste.
Peat	decayed plant and vegetable matter which is dried for fuel or fertiliser.
Phloem	the tissue responsible for transporting food throughout a plant.
Polygyny	where both males and females mate with more than one partner during a breeding season.
Potable	drinkable.
Prophylactic	a preventative measure or medication for guarding against disease.
Reservoir	an extra supply or store.
Sap	the juice or vital circulating fluid, especially of a woody plant.

Sclerophyll	any of various plants, typically found in low rainfall areas, having tough leaves which help to reduce water loss.
Social	living in a community; not solitary.
Solitary	living alone; single.
Substrate	the base or material on which an organism lives i.e soil, pine bark, concrete.
Territory	the area which an animal or a pair of animals claim as their own and defend against intruders.
Thermoregulating	ability to self-regulate body temperature.
Vulnerable	weak, in respect of defence.

16 Appendix

Appendix 1

Appendix 2

Appendix 3

MILK PREPARATION

WIRES Training Manual. Rescue and Rehabilitation and Release of Possums & Gliders. Pgs 189-191.

16 Appendix

Appendix 1

Table 1. A subjective classification of calls made by Yellow-bellied Gliders in north Queensland, with comments on their function and occurrence.

Call	Description of sounds	Remarks
"Full-call"	Begins with high pitched syllables, tails off in a series of throaty sounds "Skree-skrr-skree-skrr-chuga-chuga-chuga-chuga".	Used by both sexes; often sounded just after animal arrives at a tapped tree, or after similar call is heard.
"Full-call" preceded by "whoo"	The "whoo" is a soft, short note, as for gliding "whoo", described below.	Rarely used. Heard only from one dominant male.
"Full-call" preceded by "squeak"	The squeak sounds as though produced on an indrawn breath.	Rarely heard.
Appeasement version of "Full-call"	A thin squeaky low-volume version of the "full-call".	Heard from females only; sounded when running away from an aggressive approach by a group member; also used after pursuit or attack is concluded.
"Purring", "churring", "chirruping"	Polysyllabic, low volume.	During affectionate meetings, usually used by dominant male towards adult or sub-adult female. Also during play.
Squeal	Single note, soft or moderately loud.	During play in tree tops, perhaps by a player which gets hurt.
"Jabber"	"Skree-chuga-chuga-chuga-chuga", repeated many times.	Usually from crown or upper branches of a tree. Animal seems restless. Call may signify agitation.
"Judder"	Like the chattering of a human's teeth.	Rarely heard; low volume but penetrating. Follows each burst of "Jabber" when "Jabber" has gone on for a long time.
"Whoo"	Single note, low volume.	Often used; immediately after the start of a glide.
"Whoop-whoop-whoop-"	Like a Coucal in the distance, short notes, quickly repeated, producing a pulsating effect.	Only used during glides. Often used during long glides.
"Rattling"	"Chuga-chuga-chuga-chuga".	Very loud, throaty. Only when gliding. Often heard on nights when gliders are travelling widely.
"Chatter"	"Self-starter" noise; burst of continuous grating sounds, like a klaxon.	When caught by a human, or hurt by another glider.
"Wook"	Short note, plaintive sound, repeated frequently.	Only heard once, during a fight, perhaps from animal suffering injury.
"Pheeah"	Non-vocal. A prolonged hiss of expelled air.	Defensive, by animal seeking to deflect a charge or assault by a group member.
"Panting"	Non-vocal. Short bursts of expelled air, much repeated.	Used with varying emphasis by dominant or low rank animals — self-announcing, but with a deprecatory or assertive intent according to rank of user.
Buccal clicks	Non-vocal, soft clicking.	Heard once, when a male and female were moving about together with female possibly in oestrus

Appendix 2 **Identified Yellow-bellied Glider Sap Tree Species in NSW**

Scientific Name	Common Name/s	Region
Acacia mabellae	Mabel's Wattle	South Coast
A. mearnsii	Black Wattle	South Coast
Angophora subvelutina	Broad-leaved Apple	North-east
Corymbia gummifera	Red Bloodwood	South Coast
C. henryi	Large-leaved Spotted Gum	North-east
C. intermedia	Pink Bloodwood	North-east
C. maculata	Spotted Gum	South Coast, North-east
Eucalyptus amplifolia	Cabbage Gum	North-east
E. andrewsii	New England Blackbutt, Gum-topped Peppermint	North-east
E. angophoroides	Apple-topped Box	South Coast
E. bancroftii	Orange Gum, Bancroft's Red Gum	North-east
E. bosistoana	Coast Grey Box	South Coast
E. botryoides	Bangalay, Southern Mahogany	South Coast
E. cypellocarpa	Monkey Gum, Mountain Grey Gum	South Coast
E. dalrympleana	Mountain Gum	Southern Tablelands
E. deanei	Mountain Blue Gum, Round-leaved Gum	North Coast and adjacent ranges
E. dunnii	White Gum	North-east
E. eugenioides (includes *E. nigra*)	Thin-leaved Stringybark	North-east
E. fastigata	Brown Barrel, Cut-tail	Southern Tablelands
E. grandis	Flooded Gum, Rose Gum	North-east
E. laevopinea	Silvertop Stringybark	North-east
E. moluccana	Grey Box	North-east
E. obliqua	Messmate	South Coast, North-east
E. ovata	Swamp Gum	South Coast, Southern Tablelands
E. pilularis	Blackbutt	North-east
E. pilularis/*C. maculata* hybrid		South Coast
E. piperita	Sydney Peppermint	South Coast
E. propinqua	Grey Gum	North-east
E. punctata	Grey Gum	Central Coast, South Coast, North Coast and adjacent ranges
E. racemosa	Narrow-leaved Scribbly Gum	North Coast
E. saligna	Sydney Blue Gum	North Coast and adjacent ranges, South Coast
E. sclerophylla	Hard-leaved Scribbly Gum	South Coast
E. seeana	Narrow-leaved Red Gum	North-east
E. signata	Scribbly Gum	North-east
E. tereticornis	Forest Red Gum	North Coast and adjacent ranges
E. viminalis	Ribbon Gum, Manna Gum	South Coast, Southern Tablelands
Lophostemon confertus	Brush Box	North Coast

Source:
Bell and Bell (1997); Ecotone Ecological Consultants (1995a, 1995b); Goldingay and Kavanagh (1990); Goldingay (1986, 1987, 1989a, 1989b, 1990, 1991, 2000); Kavanagh (1984, 1987a, 1987b); Mackowski (1988, unpub. in Smith and Russell 1982); Smith *et al.* (1994).

Also see Threatened Species Licences of the IFOA for the Eden Region, Southern Sub-region and Tumut Sub-region.

Appendix 3

MILK PREPARATION

WIRES Training Manual. Rescue and Rehabilitation and Release of Possums & Gliders. Pgs 189-191.

Equipment:

- Milk Replacement Formula Powder
- Digital scales
- Measuring jug
- Clean, dry spoon
- Water
- Whisk (hand, battery or electric)
- Sterile bottle with lid

1. Wombaroo

a) <0.8 Possum Milk- To make 100mls milk. Use 16gms powder.

- Boil water and let it cool until warm.
- Pour 40mls of the pre-boiled, warm water into the measuring jug.
- Sit the jug with water on the scales and take them to zero.
- Open the packet of the <0.8 Possum Milk carefully, and spoon enough powder into the jug of water to weigh 16gms.
- Take the jug off the scales.
- Whisk the powder into the water. Very hot water will make the milk curdle. Cold water will not dissolve the milk, which will go lumpy.
- When the mixture is smooth, remove the whisk.
- Add water UP TO the 100ml level.
- Whisk again.
- Pour the milk into the sterilized jar, put the lid on securely.
- Label the jar with the type of milk and the date made up.
- Put the jar into the fridge.
- Put the opened packet of milk into an airtight plastic or glass container, label it and put it into the fridge.
- Make up a new batch of milk every second day.
- Only pour enough milk into medicine glass/ syringe for each feed.
- Never reheat milk left over from a feed.

b) > 0.8 Possum Milk- To make 100mls Milk. Use 25gms powder.

- Boil water and let it cool until warm.
- Pour 40mls of the pre-boiled, warm water into the measuring jug.
- Sit the jug with water on the scales and take them to zero.
- Open the packet of the > 0.8 Possum Milk carefully, and spoon enough powder into the jug of water to weigh 25gms.

- Take the jug off the scales.
- Whisk the powder into the water. Very hot water will make the milk curdle. Cold water will not dissolve the milk, which will go lumpy.
- When the mixture is smooth, remove the whisk.
- Add water UP TO the 100ml level.
- Whisk again.
- Pour the milk into the sterilized jar, put the lid on securely.
- Label the jar with the type of milk and the date made up.
- Put the jar into the fridge.
- Put the opened packet of milk into an airtight plastic or glass container, label it and put it into the fridge.
- Make up a new batch of milk every second day.
- Only pour enough milk into medicine glass/ syringe for each feed.
- Never reheat milk left over from a feed.

2. Biolac

a) **M100G**- To make 100mls milk. Use 16gms powder.

- Boil water and let it cool until warm.
- Pour 40mls of the pre-boiled, warm water into the measuring jug.
- Sit the jug with water on the scales and take them to zero.
- Open the packet of the M100G Possum Milk carefully, and spoon enough powder into the jug of water to weigh 16gms.
- Take the jug off the scales.
- Whisk the powder into the water. Very hot water will make the milk curdle. Cold water will not dissolve the milk, which will go lumpy.
- When the mixture is smooth, remove the whisk.
- Add water UP TO the 100ml level.
- Whisk again.
- Pour the milk into the sterilized jar, put the lid on securely.
- Label the jar with the type of milk and the date made up.
- Put the jar into the fridge.
- Put the opened packet of milk into an airtight plastic or glass container, label it and put it into the fridge.
- Make up a new batch of milk every second day.
- Only pour enough milk into medicine glass/ syringe for each feed.
- Never reheat milk left over from a feed.

b) **M100**- To make 100mls milk. Use 16gms powder.

- Boil water and let it cool until warm.
- Pour 40mls of the pre-boiled, warm water into the measuring jug.
- Sit the jug with water on the scales and take them to zero.
- Open the packet of the M100 Possum Milk carefully, and spoon enough powder into the jug of water to weigh 16gms.
- Take the jug off the scales.
- Whisk the powder into the water. Very hot water will make the milk curdle. Cold water will not dissolve the milk, which will go lumpy.
- When the mixture is smooth, remove the whisk.
- Add water UP TO the 100ml level.
- Whisk again.

- Pour the milk into the sterilized jar, put the lid on securely.
- Label the jar with the type of milk and the date made up.
- Put the jar into the fridge.
- Put the opened packet of milk into an airtight plastic or glass container, label it and put it into the fridge.
- Make up a new batch of milk every second day.
- Only pour enough milk into medicine glass/ syringe for each feed.
- Never reheat milk left over from a feed.

3. Divetelact or Digestelact

To make 100mls milk. Use 10gms powder or 1 scoop of powder.

- Boil water and let it cool till warm.
- Pour 100mls of the pre-boiled, warm water into the measuring jug.
- Using:
    - 10gms Powder: set the jug with water on the scales and tare them to zero, spoon 10gms of powder into the jug.
    - 1 scoop: open the packet or tin carefully and scoop up the milk powder. The scoop must be well packed and leveled off. Empty scoop of milk into the jug.
- Whisk the powder into the water.
- No need to add more water.
- Pour the milk into the sterilized jar, put the lid on securely.
- Label the jar with the type of milk and the date made up.
- Put the jar into the fridge.
- Put the opened packet of milk into an airtight plastic or glass container, label it and put it into the fridge.
- Divetelact/ Digestelact can be made up to a more concentrated formula when the joey is tolerating the milk.
- Additives may include-
    - 2 drops olive oil per 50mls milk.
    - 2 drops Pentavite per 50mls milk.
    - ¼ teaspoon Farex per 50mls milk.

Aust. J. Zool., 1992, **40**, 267–78

Socioecology of the Yellow-bellied Glider (*Petaurus australis*) in a Coastal Forest

Ross L. Goldingay

Biology Department, University of Wollongong,
Wollongong, N.S.W. 2500, Australia.

Abstract

The social organisation of the yellow-bellied glider was examined at Kioloa in southern New South Wales. Gliders lived in family groups that initially included several adult females and, in one instance, two females in the same group lactated concurrently, suggesting that gliders at this site are capable of polygyny. Group size at this time numbered five to six individuals but later declined to three individuals (an adult pair with offspring), coinciding with three consecutive years of flower failure by *Eucalyptus maculata*, the major winter food resource. Mean group size between 1986 and 1989 was 4·2 individuals. Females gave birth predominantly between February and April, which is several months earlier than at other sites in southern Australia and which is presumed to be determined by the availability of certain food resources. Home ranges of glider groups were exclusive and averaged 34 ha (minimum convex polygon). Glider density averaged 0·10–0·16 individuals per ha. Parallels are drawn between the socioecology of gliders at this site and that in north Queensland and contrasted with that at other sites in southern Australia.

Introduction

The yellow-bellied glider (*Petaurus australis*) represents one of the few examples among marsupials of a species with a variable mating system (E. M. Russell 1984). In southern Australia, this species displays a monogamous mating system (Henry and Craig 1984; Craig 1985; Goldingay and Kavanagh 1990) but in northern Australia, gliders live in polygynous groups that occasionally revert to monogamy (R. Russell 1984). Lee and Cockburn (1985) inferred that the geographic disparity between these sites incorporated differences in food availability and foraging costs which favoured different mating systems. More recently, Macdonald and Carr (1989) have argued that the pattern of resource availability, predictability and dispersion is a primary determinant of an animal's social organisation.

This study examines the social organisation of the yellow-bellied glider in a coastal forest in southern New South Wales. Here, the main food resources were eucalypt nectar and pollen (Goldingay 1990). These resources have a spatio-temporal pattern of distribution dissimilar to that of other food resources such as sap, honeydew and arthropods, which are more common in the diet at other sites in southern Australia (see Goldingay and Kavanagh 1991).

Methods

Study Area

The study area in Kioloa State Forest, Kioloa (35°35′S.,150°19′E.), encompassed approximately 200 ha of mature eucalypt forest. Five species of *Eucalyptus* (*E. maculata*, *E. gummifera*, *E. pilularis*, *E. pellita* and *E. piperita*) dominated the site. The height of the forest canopy was approximately 30–45 m throughout the site. The area bounded to the east by Cousins Gully Road and Link Road

0004-959X/92/030267$05.00

(Fig. 1) had been heavily logged within the last 20 years and contained only a small number of large hollow-bearing trees. The average daily temperatures for the area were rarely below 10°C in winter and rarely above 25°C in summer, and the annual average rainfall for Batemans Bay, which is approximately 20 km to the south-west, is 1008 mm (Pook 1984, 1986). Fieldwork was conducted during 19 field trips of 5–14-nights duration between February 1985 and August 1989.

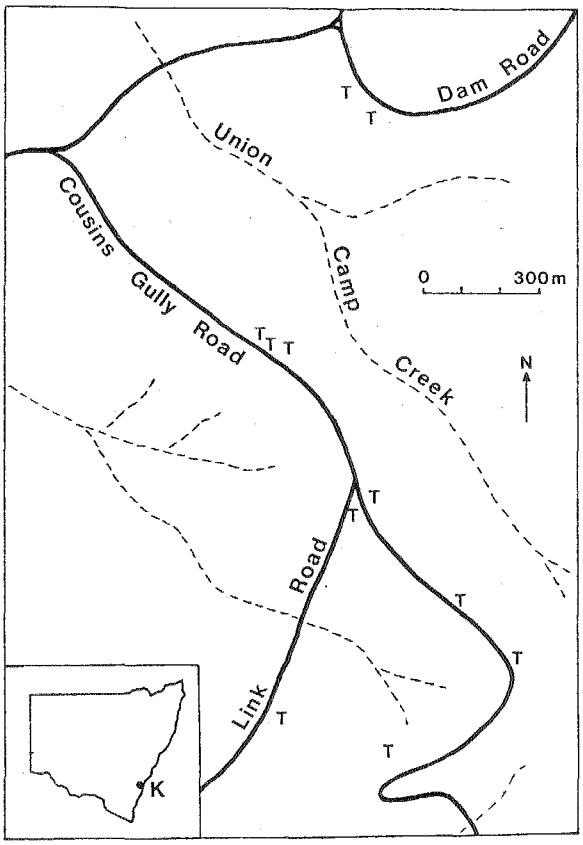


Fig. 1. The location of tree-traps (T) in the study area at Kioloa. The inset shows the location of Kioloa on the south coast of N.S.W.

Trapping of Gliders

Beginning in 1986, wire cage traps (measuring 20 × 20 × 56 cm) were attached to horizontal platforms on tree trunks and placed at heights of 2–8 m above the ground. Traps were baited with creamed honey and a honey-water solution was squirted from an oil can onto the trunk above the trap in order to lure animals down into traps. Trap platforms were attached to 11 trees (Fig. 1), eight of which had permanent ladders erected on them similar to those employed by Smith (1984*a*). Eight of the trap-trees provided either sap or honeydew for gliders and were the most intensively used exudate trees in the study area. The three additional trap-trees were located in areas frequented by gliders at a time when the exudate trees were not being visited.

Captured gliders were weighed and their sex determined, reproductive condition noted and dentition examined. Adult gliders were distinguished by their deep-yellow ventral fur, and by the presence of cracked and discoloured incisor teeth. The incisor teeth of gliders at this site did not show the noticeable wear observed elsewhere in this species (see Goldingay and Kavanagh 1990). Subadults could be distinguished by their white ventral fur (which could be detected with binoculars when animals were illuminated by a spotlight), their white incisors and the lack of any sign of sexual maturity (Goldingay and Kavanagh 1990). The latter was indicated in males by a non-active scent gland on the head and in females by a very shallow pouch with small teats.

Metal tags (fingerling fishtags) were attached to the ears of gliders. A piece of coloured reflective 'Scotchlite' tape was attached to each tag, giving a unique colour-tag–ear combination which enabled identification of individuals by spotlight (Goldingay and Kavanagh 1990). In addition, four gliders were fitted with collars containing radio-transmitters for varying lengths of time. This provided few data because of the difficulty of recapturing gliders in order to maintain the transmitters.

Census of Glider Groups

During field trips, a spotlight (100 W, 12 V) was used to locate yellow-bellied gliders in order to observe their foraging behaviour (Goldingay 1990, 1991). By 1987, the approximate location of three glider groups was known and censuses were commenced to determine the number of gliders in each group. The calls of this species can be used to assess the number of individuals in an area (Kavanagh and Rohan-Jones 1982; Goldingay and Kavanagh 1991) and when coupled with observations on the use of den trees (Goldingay 1989*a*) will provide an accurate census. Extensive observations on foraging gliders from each of the three groups provided the opportunity to monitor glider calls. Den trees were located by monitoring areas at dusk where glider calls had been heard early on a previous night, or where gliders had been followed prior to their return to dens before dawn (Goldingay 1989*a*). Although den trees were not located initially, the approximate position (within 1 ha) was determined for the three groups under study and the number of gliders departing (at dusk) and arriving (at dawn) from that area was assessed. Two observers were often employed to do this. These censuses are considered accurate because glider density is typically low and the number of individuals within a group changes by only one or two within a year (Goldingay and Kavanagh 1990, 1991).

Reproduction

The reproductive condition of captured female gliders was determined by examination of their pouch. Females were classified as non-breeding (teats small) or breeding. The latter was indicated when a pouch young was present or when the teats indicated that females were lactating (Goldingay and Kavanagh 1990). In such instances nestlings were inferred to be present in the den hollows and occasionally were observed.

Estimation of Home Range

Locations used in the home-range analysis were based both on sightings of gliders and occasionally on vocalisations when a calling glider was not seen but its group identity was known. Only a single location was obtained per individual per night unless locations were widely spaced or separated by more than 3 h. These data represent independent observations that are preferred in such analyses because the use of multiple locations from animals followed continuously may lead to an underestimate of the home-range area (Swihart and Slade 1985). Many location records were obtained for untagged gliders from each of the three groups but were used only when the den from which a glider originated was known. Regularly following gliders (both tagged and untagged) from their dens whilst conducting detailed observations on their foraging behaviour revealed that there was little overlap in adjacent home ranges. The den area from which a glider originated was known in all instances where gliders were recorded near their home-range boundaries.

The home-range areas of glider groups were estimated using the MCPAAL programme (Stuwe and Blohowiak 1985). Three methods were used to estimate this: the minimum convex polygon (MCP), the 95% isopleth of the harmonic mean distance minimum (Dixon and Chapman 1980) and the Fourier transform method (MAP) (minimum area *v.* probability of 95%: Anderson 1982).

Results

Trapping

Between February 1986 and May 1989, 32 captures of gliders were made from 421 trap-nights, averaging 7·6% trap success. This represented 16 individuals from three distinct home ranges. There was no statistically significant difference ($\chi^2 = 0{\cdot}77$, $P > 0{\cdot}25$) when trap success at Kioloa was compared with that obtained at Waratah Creek, Bombala (Goldingay and Kavanagh 1990). Half of the captures were made in 1986 when gliders fed extensively on *E. gummifera* sap in August and *Acacia* sap throughout much of the year.

The three non-exudate trap-trees failed to provide any captures. Weights of adult male gliders (635·8±31·2 g, mean±s.e.; $n=6$; range 555–725 g) were significantly ($t=2·22$, d.f.=12, $P<0·025$) greater than weights of females (529·9±33·8 g; $n=8$; range 450–657 g). Weights of subadult males were 517·5±10·5 g ($n=4$).

Glider Groups

From February to August 1986, traps were set on only four of the 11 trap-trees within the study area. Eleven gliders were captured in two separate groups, later designated Groups 1 and 3. Group 1 contained an untagged glider in addition to the five tagged individuals. Therefore, the two groups each had six members for periods of time (Table 1). The individuals within a group were observed either feeding or foraging in close proximity without showing any hostility toward each other.

Table 1. Number of gliders in three groups at Kioloa, N.S.W.

Dashes indicate incomplete censuses

Census period		Group 1	Group 2	Group 3
1986	April	–	–	6
	August	6	–	5
	December	4	–	–
1987	April	4	4	4
	July	4	–	–
	September	4	–	4
	December	–	4	–
1988	June	3	3	3
1989	January	3	–	3
	May	3	4	3

Initially, Group 1 consisted of the one glider that was never captured, one adult male, three adult females (two were lactating when captured in August) and one subadult female. The skeleton of an individual (no ear-tag located) was found in December 1986 at the base of an intensively used sap-site tree in the home range of this glider group. By this time, and throughout 1987, this group numbered four individuals. Censuses in 1988 and 1989 indicated only three individuals (two adults and one subadult) living in this home range (Table 1).

Group 3 included six individuals when first censused in 1986 (Table 1): one adult male, two subadult males, two adult females and a juvenile male. The latter, captured in February 1986, was half the size of the other gliders and was not seen after April 1986. This group numbered five individuals in August 1986 and limited observations indicated that it was divided between two den trees within 100 m of each other (Fig. 2). This group numbered four individuals in April 1987 and three in 1988 and 1989 (Table 1). The counts of three were of two adults and one subadult. A third den tree was used by this group in 1988 and 1989.

Although 11 gliders were tagged in Groups 1 and 3 in 1986, censuses of these and Group 2 throughout 1987 indicated that only one of the tagged gliders was still present. Close examination of gliders, through binoculars and when trapped, indicated that none of those remaining were individuals that had lost ear-tags.

Group 2 was identified in December 1986 and initial attempts to capture these gliders failed. Throughout 1987, this group numbered four individuals that shared a den tree to the west of Link Road (Fig. 2). This number declined to three in June 1988 (two adults and one subadult) so that the number in each of the three groups was equivalent (Table 1). These instances of three individuals presumably represent a breeding pair with offspring.

This year (1988) was the third successive year in which the chief winter food resource, *E. maculata* blossom, had failed to develop. In May 1989, this group numbered four, including two subadults, one of which received some hostility from the adult male.

The three glider groups tended to use the same den trees (or at least den trees in the same area) for long periods (more than 12 months). Group 1 denned in the same area from at least April 1987 to May 1989; Group 2 was known to use only two den trees from April 1987 to August 1989 and Group 3 denned in the same area from April 1987 to May 1989. Overall, group size averaged $4{\cdot}2 \pm 0{\cdot}4$ (mean $\pm$ s.e.; $n = 10$) if each change in group size is treated as a separate record.

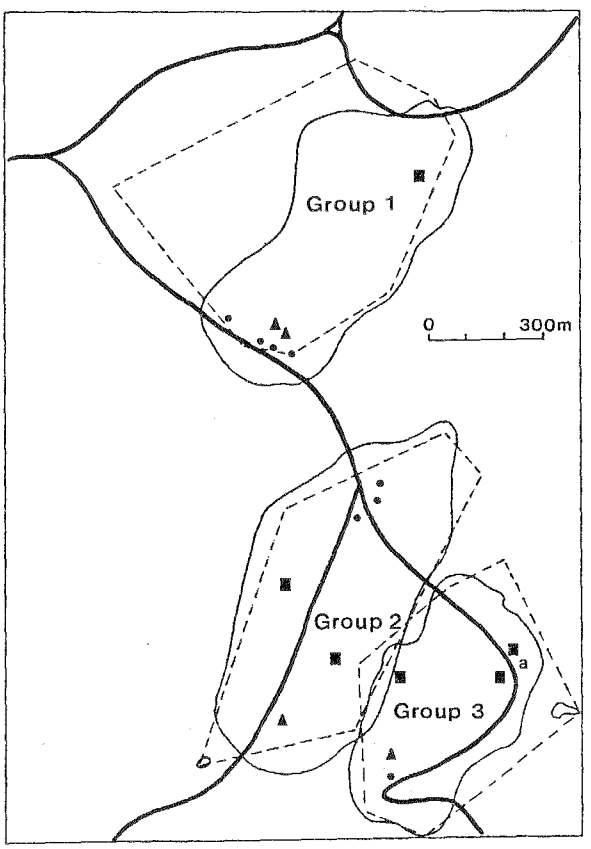


Fig. 2. Home-range boundaries of the three glider groups at Kioloa. The minimum convex polygon (MCP) is indicated by the dashed line. The 95% isopleth is indicated by the solid line. Note that this isopleth has a small isolated area for Groups 2 and 3. ■, position of den trees; ●, *E. gummifera* sap-site trees; ▲, *E. piperita* honeydew feeding trees; a, position of an *Acacia mabelliae* tree used for sap feeding.

Reproduction

Reproductive status was determined for nine adult female gliders, and eight reproductive episodes were observed. Only a single teat was observed to be in use for any female, indicating that a single young was reared. Estimating the month of birth by assuming a pouch life of 100 days and nestling life of 50 days (see R. Russell 1984) revealed that six of the young were born between February and April (Table 2).

Table 2. Reproductive events recorded from captured females and/or den observation

See text for determination of month of birth. NB, non-breeding; ET, elongated teat indicating late lactation or recent conclusion of it; PY, pouch young; L, lactating; N, nestling observed

Female No.	Group	Date of capture	Event	Extrapolated month of birth
638	3	August 1986	ET	February–March 1986
645	3	August 1986	NB	
640	1	August 1986	NB	
641	1	August 1986	NB	
637	1	August 1986	ET	February–March 1986
643	1	August 1986	ET	February–March 1986
		October 1986	NB	
		May 1987	ET	November–December 1986
1	2	July 1987	NB	
853	3	December 1987	ET	June–July 1987
		April 1988	PY	April 1988
		May 1989	L	February 1989
U	2	May 1989	PY–N	February 1989

Two females from Group 1 were observed lactating in August 1986, and it was estimated that the young of these females were born in February–March. One of these females (No. 643) was again captured in May 1987 with an indication (i.e. elongated teat) of having recently completed lactation. This was extrapolated to the birth of a young in November–December 1986. Thus, this female had given birth to two young within 11 months. Another female (No. 853) reproduced three times between June 1987 and February 1989 (i.e. a period of 21 months). It is not known whether this frequency of births was related to the early mortality of pouch young.

In May 1989, an untagged female in Group 2 was observed with an obvious pouch young that could be seen through the pouch opening, occasionally with its tail hanging down. After several nights the pouch young was missing and was believed to have been deposited in the den to which the female was observed returning during the night. A nestling was observed climbing in, but not leaving, this den tree 90 days later. The adult female (No. 853) from Group 3 was observed lactating in May 1989 and also was observed returning to its den on several occasions during the night.

Longevity

Few data have been obtained on longevity at Kioloa. Only one individual captured in 1986 was seen or captured subsequently. It is assumed that individuals are 2 years of age when they become resident in a home range (Goldingay and Kavanagh 1990). Therefore, this individual (No. 643) was at least 4·5 years old when last seen in January 1989. Another female (No. 853), presumably present in June–July 1987 (i.e. the extrapolated month of birth of its young), was still present in August 1989 when at least 4 years old. Male No. 817, first captured in May 1987, was still present in January 1989 when at least 3·75 years old. Another male (No. 822), first captured in July 1987, was still present in August 1989 when at least 4 years of age. No data were obtained on survival or dispersal of young at Kioloa.

Home-range Estimates and Glider Density

One individual of Group 1 persisted from August 1986 to January 1989 and was observed at all corner locations of the MCP boundary (Fig. 2). Although this glider was not observed

subsequently, the group in this home range continued to use a den tree in approximately the same area. Therefore, observations on gliders from this home range include the period 1986–89. Observations for Groups 2 and 3 are for the period 1987–89.

The different techniques for estimating home ranges gave similar mean values (30–37 ha) for the size of the home ranges at Kioloa (Table 3). The harmonic mean method gave values that were, on average, 94% of the average minimum convex polygon (MCP) value, while the MAP (95%) indices were 117% of the MCP value. There was slight overlap between the home ranges of two of the glider groups (Fig. 2) but there was no known overlap between the three study groups and any other groups.

Table 3. Determination of the home-range area (ha) of yellow-bellied gliders

N, number of locations; MCP, minimum convex polygon; 95% isopleth, harmonic mean minimum method; 95% MAP, Fourier transform method

Glider group	*N*	MCP	95% isopleth	95% MAP
1	55	40·6	30·5	52·2
2	88	29·5	36·5	31·1
3	86	24·7	21·9	27·2
Mean ± s.e.		31·6 ± 4·7	29·6 ± 4·2	36·8 ± 7·8

One shortcoming of these estimates is that the number of locations may have been insufficient to determine the size of home ranges accurately. This can be assessed by repeatedly removing, at random, a specified number of the locations from the data set until only a few remain (Jaremovic and Croft 1987). Initially, locations were removed at random for the three groups to reduce each data set to a multiple of 10 and the MCP home-range area estimated. Subsequently, 10 locations were chosen at random, removed from each data set and the MCP area estimated. This was repeated until only 20 locations remained. This procedure was repeated 10 times for each group in order to give an estimate of variance for each resulting sample size.

Graphing the home-range area against increasing sample size indicates whether an adequate sample size was used to estimate home-range size of each glider group. The MCP area for Group 3 levelled off after 60 locations whereas that for Group 2 did so at 80–90 locations (Fig. 3). Group 1 had fewer observations and a larger MCP estimate, which had not reached an asymptote for the full data set of 55 locations, suggesting that the home range of this group has been underestimated. The Group 2 graph was used (because it required more data than that of Group 3) to provide an extrapolation of the home-range area of Group 1, which would have been seen if more data were available. After 55 locations, the home-range area for Group 2 was 85% of that for the total data set. Thus, if this were the same for Group 1, its home-range estimate would be 47·8 ha. Using this value, the mean (± s.e.) home-range area for the three groups is 34·0 ± 7·1 ha.

The area of the above home ranges (MCP) was used to determine the density of gliders at Kioloa. The size of the home ranges was assumed to be constant as group size changed. Maximum density (0·16 gliders per ha) occurred in August 1986 when Group 1 comprised six individuals and Group 3 comprised five. The minimum density (0·10 ± 0·01 gliders per ha) occurred in June 1988 when there were three gliders in each of the three home ranges.

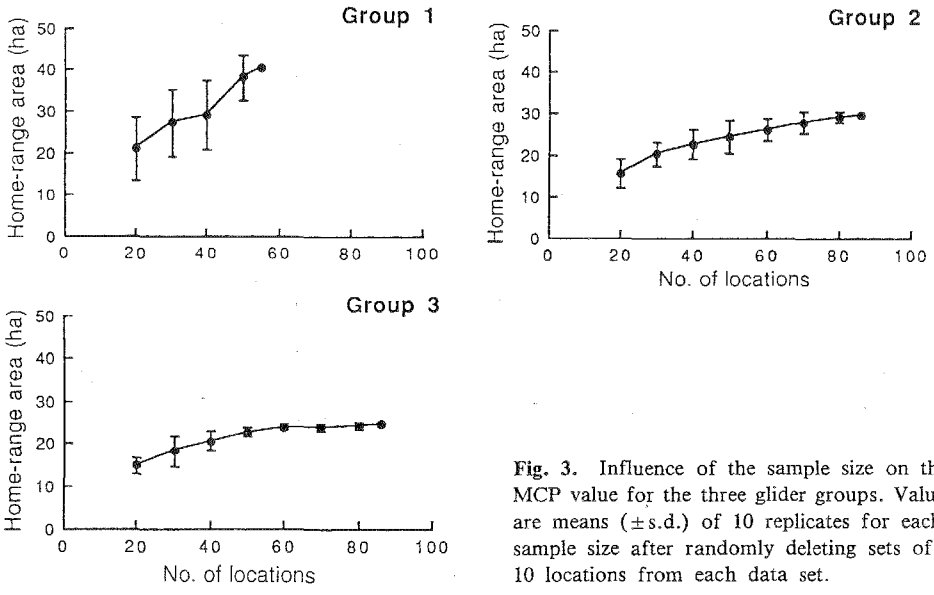


Fig. 3. Influence of the sample size on the MCP value for the three glider groups. Values are means (±s.d.) of 10 replicates for each sample size after randomly deleting sets of 10 locations from each data set.

Discussion

Social Organisation of Gliders

Of fundamental importance in a consideration of the social organisation of the yellow-bellied glider is the type of mating system observed, defined here as the presumed mating relationship between adult animals (cf. Emlen and Oring 1977). Lee and Cockburn (1985) implied that there was a stark contrast in the mating system of the yellow-bellied glider between north Queensland and southern Australia. The latter situation, where gliders are monogamous, is now represented by studies at three sites in comparable habitat (see Goldingay and Kavanagh 1990). However, research at Kioloa (also in southern Australia) indicates a situation analagous to that described in north Queensland, where gliders may alternate between polygynous and monogamous groups (see R. Russell 1984). At both sites, glider groups in some years comprised monogamous pairs with offspring but in other years comprised six individuals, including several adult females with one adult male. Further evidence of a polygynous mating system at Kioloa was the observation of two concurrently lactating females in the same group.

Lee and Cockburn (1985) considered that the continuous availability of food resources, particularly arthropods, in north Queensland was responsible for the polygynous mating system of gliders. Such a description could be used for Kioloa where the staggered flowering periods of the five eucalypt species allowed blossom to be available throughout the year, although in varying abundances (see Goldingay 1990). This provided a continuous supply of both nectar (i.e. energy) and pollen (i.e. protein). The nectar resources were, on average, in greater abundance (measured as the number of trees providing food) than all exudate resources (sap, honeydew, manna and nectar) at Bombala (see below) where only monogamy has been observed (Goldingay and Kavanagh 1990). However, large group sizes and polygyny at Kioloa may be dependent on successive years of abundant flowering by *E. maculata*. For example, glider groups at Kioloa comprised 5–6 individuals when first monitored but later declined to 3 individuals. This followed three successive years of flower failure by *E. maculata*, which was the most abundant eucalypt in the study area and had the longest (April–September) flowering period (Goldingay 1990). Within-group competition for scarce

food when few *E. maculata* flower may push time-budgets of large groups to unacceptable limits (Schaik *et al.* 1983), leading to a reduction in group size and consequent reversion to monogamy.

Monogamy is considered to evolve when food resources are limiting, thereby preventing social grouping, and where breeding success depends on male parental investment (Emlen and Oring 1977; Wittenberger and Tilson 1980; Rutberg 1983). Territorial defence appears to be the main form of parental investment provided by male yellow-bellied gliders (Goldingay 1989*b*). Therefore, polygyny should occur where food resources are sufficiently abundant to allow a male glider to defend an area that can support more than one female. Sites (e.g. Kioloa) where home ranges are substantially smaller than those where only monogamous groups occur (e.g. Bombala) will be indicative of polygyny.

Polygyny should occur at other sites in southern Australia where there is a combination of certain eucalypt species that are capable of providing abundant food resources throughout the year, particularly where an abundant eucalypt species has a flowering period spanning the winter months. Arthropod abundance is typically considered the major constraint on reproduction for petaurid marsupials (Smith 1982; Goldingay and Kavanagh 1990), and possibly on group size also, but its role may be replaced where eucalypt blossom is abundant and protein is provided by pollen.

Reproduction

Gliders at Kioloa gave birth predominantly (75% of records) in February–April, which precedes the breeding period at other sites by several months. At Bombala, 70% of young are produced in July–September (Goldingay and Kavanagh 1990). At a variety of sites in Victoria, 69% of young are produced in August–December whilst in north Queensland 63% of pouch young are produced between May and September (Craig 1986). Such seasonality may result from synchronisation with the most prolific food resource. Ward (1990) suggested that differences among sites in the time when eastern pygmy possums (*Cercartetus nanus*) gave birth are related to the different patterns of flowering at different sites. At Kioloa, nectar feeding is the predominant feeding behaviour throughout the year and gliders are able to digest pollen which would provide dietary protein (Goldingay 1990). Thus, in a good year (i.e. when all species flower), nectar and pollen may be available throughout the year and, therefore, neither exudates nor protein are clearly seasonal. This provides a third pattern of food availability to the two suggested by Smith (1982, 1984*b*), where protein or energy may show a seasonal abundance.

Probably the most important resource at Kioloa was the winter flowering of *E. maculata*. When it flowered fully (e.g. 1985, 1989), this resource persisted from at least April to September (Goldingay 1990). This may ensure that females undergo late lactation in July and that young gliders emerge from their dens when *E. maculata* is in flower in August. One apparent inconsistency here is that many of the breeding records (6 of 8) came from years (1986–88) in which *E. maculata* failed to flower. However, group sizes declined through this period, suggesting mortality or dispersal of both adults and offspring. If conception is dependent on body condition (e.g. Schaik and Noordwijk 1985; Ward 1990), then the births in early 1986 may have followed the good flowering of *E. maculata* in 1985. Alternatively, gliders may be unable to predict whether a food resource, such as a flower crop of one species, will eventuate and therefore may reproduce anyway. If food becomes scarce at a later date, then the young can be aborted. In fact, this situation has been documented for Leadbeater's possum (*Gymnobelideus leadbeateri*) where the population density declined by 45% in one year, presumably in response to a shortage of food, despite all captured resident females having reproduced prior to this decline (Smith 1984*a*).

Home-range Area

Several authors have reiterated the influence of energy requirements (i.e. body mass) and diet on home-range size but state that this relationship is complex (Harvey and Clutton-Brock 1981; Mace and Harvey 1983). For some species, this apparent complexity may result from different habitats creating intraspecific variation (Gittleman and Harvey 1982; Gompper and Gittleman 1991). For example, the average home-range size of yellow-bellied gliders at Kioloa was 34 ha (MCP), which is 54% of that at Bombala (Goldingay and Kavanagh, unpublished data); this difference is probably a reflection of more abundant food resources at Kioloa. An assessment of the number of flowering trees at Kioloa (Goldingay 1989*b*) during field trips between April 1987 and August 1989 shows that flowering trees averaged 3·9±2·2 (s.e.) per ha (i.e. 133 per home range) at any time. In contrast, only a small number of trees (less than 7) were ever used for any sort of exudate feeding at Bombala in a given home range (Goldingay 1986, 1987, 1989*a*). Thus, for an average home range at Bombala of 63 ha (Goldingay and Kavanagh, unpublished data), exudate trees averaged 0·1 per ha. Presumably, this greater productivity at Kioloa has resulted in the small home ranges (approximately 30–40 ha) and large group sizes (4·2 individuals), leading to the higher density of gliders (0·10–0·16 per ha) than at Bombala (0·04–0·07 per ha: Goldingay and Kavanagh, unpublished data).

Lee and Cockburn (1985) alluded to a temperate/tropical eucalypt forest dichotomy to explain the difference in the pattern of food abundance, and gave further support by comparing the expansive home ranges (40–60 ha) of gliders in southern Australia with the small home ranges (2 ha) suggested for gliders in north Queensland by R. Russell (1984). This comparison is misleading because Russell suggested that one glider group had a home range of 30 ha, which is comparable to that at Kioloa. Moreover, Russell has probably underestimated the size of glider home ranges in north Queensland because most of his observations were confined to marked gliders at sap-site trees. The areas that include these trees can be readily defined as core areas and at Bombala measured 4 ha (Goldingay and Kavanagh, unpublished data). Therefore, 30 ha should be considered closer to the true value of the home-range area in north Queensland until a proper assessment is made.

Acknowledgments

I am very grateful to the Joy London Fund and the Ecological Society of Australia for financial support during this study. The Edith and Joy London Foundation provided very welcome facilities at the Kioloa field station. Many able people provided much needed field assistance, in particular S. Carthew, J. Howard, M. Andren, C. Stephenson. Dr Sue Carthew and Darren Quin kindly provided many useful comments on an earlier draft of this paper. This is contribution No. 90 from the Ecology and Genetics Group at the University of Wollongong.

References

Anderson, D. J. (1982). The home range: a new non-parametric estimation technique. *Ecology* **63**, 103–12.

Craig, S. A. (1985). Social organization, reproduction and feeding behaviour of a population of yellow-bellied gliders, *Petaurus australis* (Marsupialia: Petauridae). *Australian Wildlife Research* **12**, 1–18.

Craig, S. A. (1986). A record of twins in the yellow-bellied glider (*Petaurus australis* Shaw) (Marsupialia: Petauridae) with notes on the litter size and reproductive strategy of the species. *Victorian Naturalist* **103**, 72–5.

Dixon, K. R., and Chapman, J. A. (1980). Harmonic mean measure of animal activity areas. *Ecology* **61**, 1040–4.

Emlen, S. T., and Oring, L. W. (1977). Ecology, sexual selection and the evolution of mating systems. *Science* **197**, 215–23.

Gittleman, J. L., and Harvey, P. H. (1982). Carnivore home-range, metabolic needs and ecology. *Behavioural Ecology and Sociobiology* **10**, 57–63.

Goldingay, R. L. (1986). Feeding behaviour of the yellow-bellied glider *Petaurus australis* (Marsupialia: Petauridae) at Bombala, New South Wales. *Australian Mammalogy* **9**, 17–25.

Goldingay, R. L. (1987). Sap feeding by the marsupial, *Petaurus australis*: an enigmatic behaviour? *Oecologia (Berlin)* **73**, 154–8.

Goldingay, R. L. (1989*a*). Time budget and related aspects of the foraging behaviour of the yellow-bellied glider, *Petaurus australis*. *Australian Wildlife Research* **16**, 105–12.

Goldingay, R. L. (1989*b*). The behavioural ecology of the gliding marsupial, *Petaurus australis*. Ph.D. Thesis, University of Wollongong, Wollongong.

Goldingay, R. L. (1990). The foraging behaviour of a nectar feeding marsupial, *Petaurus australis*. *Oecologia (Berlin)* **85**, 191–9.

Goldingay, R. L. (1991). An evaluation of hypotheses to explain the pattern of sap feeding by the yellow-bellied glider, *Petaurus australis*. *Australian Journal of Ecology* **16**, 491–500.

Goldingay, R. L., and Kavanagh, R. P. (1990). Socioecology of the yellow-bellied glider (*Petaurus australis*) at Waratah Creek, New South Wales. *Australian Journal of Zoology* **38**, 327–41.

Goldingay, R. L., and Kavanagh, R. P. (1991). The yellow-bellied glider: a review of its ecology, and management considerations. In 'Conservation of Australia's Forest Fauna'. (Ed. D. Lunney.) pp. 365–75. (Royal Zoological Society of New South Wales: Mosman.)

Gompper, M. E., and Gittleman, J. L. (1991). Home range scaling: intraspecific and comparative trends. *Oecologia (Berlin)* **87**, 343–8.

Harvey, P. H., and Clutton-Brock, T. H. (1981). Primate home-range size and metabolic needs. *Behavioural Ecology and Sociobiology* **8**, 151–5.

Henry, S. R., and Craig, S. A. (1984). Diet, ranging behaviour and social organization of the yellow-bellied glider (*Petaurus australis*) in Victoria. In 'Possums and Gliders'. (Eds A. P. Smith and I. D. Hume.) pp. 331–41. (Australian Mammal Society: Sydney.)

Jaremovic, R. V., and Croft, D. B. (1987). Comparison of techniques to determine eastern grey kangaroo home range. *Journal of Wildlife Management* **51**, 921–30.

Kavanagh, R. P., Rohan-Jones, W. G. (1982). Calling behaviour of the yellow-bellied glider, *Petaurus australis* Shaw (Marsupialia: Petauridae). *Australian Mammalogy* **5**, 95–112.

Lee, A. K., and Cockburn, A. (1985). 'Evolutionary Ecology of Marsupials.' (Cambridge University Press: Cambridge.)

Macdonald, D. W., and Carr, G. M. (1989). Food security and the rewards of tolerance. In 'Comparative Socioecology: the Behavioural Ecology of Humans and other Mammals'. (Eds V. Standen and R. A. Foley.) pp. 75–99. (Blackwell Scientific Publications: Oxford.)

Mace, G. M., and Harvey, P. H. (1983). Energetic constraints on home-range size. *American Naturalist* **121**, 120–32.

Pook, E. W. (1984). Canopy dynamics of *Eucalyptus maculata* Hook. I. Distribution and dynamics of leaf populations. *Australian Journal of Botany* **32**, 387–403.

Pook, E. W. (1986). Canopy dynamics of *Eucalyptus maculata* Hook. IV. Contrasting responses to two severe droughts. *Australian Journal of Botany* **34**, 1–14.

Russell, E. M. (1984). Social behaviour and social organization of marsupials. *Mammal Review* **14**, 101–54.

Russell, R. (1984). Social behaviour of the yellow-bellied glider, *Petaurus australis*, in north Queensland. In 'Possums and Gliders'. (Eds A. P. Smith and I. D. Hume.) pp. 343–53. (Australian Mammal Society: Sydney.)

Rutberg, A. T. (1983). The evolution of monogamy in primates. *Journal of Theoretical Biology* **104**, 93–112.

van Schaik, C. P., and van Noordwijk, M. A. (1985). Interannual variability in fruit production and the reproductive seasonality in Sumatran long-tailed macaques (*Macaca fascicularis*). *Journal of Zoology (London)* **206**, 533–49.

van Schaik, C. P., van Noordwijk, M. A., de Boer, R. J., and den Tonkelaar, I. (1983). The effect of group size on time budgets and social behaviour in wild long-tailed macaques (*Macaca fascicularis*). *Behavioural Ecology and Sociobiology* **13**, 173–81.

Smith, A. P. (1982). Diet and feeding strategies of the marsupial sugar glider in temperate Australia. *Journal of Animal Ecology* **51**, 149–66.

Smith, A. (1984*a*). Demographic consequences of reproduction, dispersal and social interaction in a population of Leadbeater's possum (*Gymnobelideus leadbeateri*). In 'Possums and Gliders'. (Eds A. P. Smith and I. D. Hume.) pp. 359–73. (Australian Mammal Society: Sydney.)

Smith, A. P. (1984*b*). Diet of Leadbeater's possum, *Gymnobelideus leadbeateri* (Marsupialia). *Australian Wildlife Research* **11**, 265–73.

Stuwe, M., and Blohowiak, C. E. (1985). 'Micro-computer Programs for the Analysis of Animal Locations.' (Smithsonian Institute: Front Royal, VA, U.S.A.)

Swihart, R. K., and Slade, N. A. (1985). Influence of sampling interval on estimates of home range size. *Journal of Wildlife Management* **49**, 1019–25.

Ward, S. J. (1990). Life history of the eastern pygmy-possum, *Cercartetus nanus* (Burramyidae: Marsupialia), in south-eastern Australia. *Australian Journal of Zoology* **38**, 287–304.

Wittenberger, J. F., and Tilson, R. L. (1980). The evolution of monogamy: hypotheses and evidence. *Annual Review of Ecology and Systematics* **11**, 197–232.

Manuscript received 30 October 1991; revised and accepted 27 March 1992