4.2. Demographics

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Abstract

The biometric and demographic attributes of woylie populations were examined as part of the Population Comparison Study (PCS). The five PCS grids in the Upper Warren and the one PCS grid at Karakamia Wildlife Sanctuary were live cage-trapped every eight weeks for 12 months (Upper Warren sites, July 2006 - June 2007; Karakamia, September 2006 – July 2007). The capture rates of woylies declined at Balban (21% to 4%), remained relatively stable and high at Karakamia (mean 77%), stable and moderate at Keninup (mean 52%) and Warrup (mean 29%), and remained low, having declined in the preceding years at Winnejup (mean 3%) and Boyicup (mean 2%).

Preliminary exploration of the data included the temporal and spatial variation in demographic attributes of the six populations. Sex ratios differed substantially between the moderate-density sites in the Upper Warren (strongly male biased) and Karakamia (strongly female biased). The prevalence of subadults was low or absent at all sites but varied temporally at Karakamia. The proportion of adult females breeding within the Upper Warren region was similar between grids and over time (overall mean of 89%) but highly seasonal at Karakamia (4% in summer to 81% in spring). Adult woylies at Karakamia were smaller than at Upper Warren sites (means of 1070 g and 1368 g, respectively). More thorough and extensive analyses of the demographic attributes of these woylie populations are planned.

4.2.1. Introduction

A comparative study of woylie populations at varying densities and stages of decline should provide evidence relating to what factors may and may not be associated with recent woylie population declines. For example, the mechanics by which a population may decline may vary substantially according to the factor(s) involved. Some factors may affect particular components of the population differently, such as individuals of different age, gender, breeding status, size or condition. Fecundity, life expectancy, and/or behaviour (e.g. emigration) may also change.

The results of a preliminary exploration of the trap capture rates and demographics of woylies at the six Woylie Conservation Research Project (WCRP), Population Comparison Study (PCS) grids are presented here. These initial findings are briefly discussed and the plans for further, more formal analyses are outlined.

4.2.2. Methods

Trapping grids were established at each of the five Upper Warren PCS sites (Keninup, Balban, Warrup, Boyicup, Winnejup; each adjacent to the associated monitoring transects) and at Karakamia Wildlife Sanctuary. The grids were trapped from July 2006 to June 2007 at the Upper Warren and from September 2006 to July 2007 at Karakamia. Trap sessions were repeated every eight weeks (i.e. approximately half the duration of the woylie breeding cycle) and were conducted simultaneously within Upper Warren region wherever possible (occasionally within the same fortnight). Each trap session was conducted over four nights an exception was the august session which was primarily conducted for applying radio transmitters here trapping ceased when radio collared targets were achieved.

Within each grid, trap points (marked by GPS-referenced metal fence droppers) were spaced 50 m apart in lines oriented to magnetic north-south and east-west. During the first trapping session at the Upper Warren sites, the grid consisted of 25 traps (5 lines of 5 traps each, i.e. 200 m x 200 m). In response to the low number of woylies captures on the low density sites, the grid was

expanded to 49 traps (7 lines of 7 traps each, i.e. 300 m x 300 m) in the aim of getting >10 woylie individuals on each of the PCS grids. These initial trap sessions indicated that grids several orders of magnitude, and well beyond available resources, would be required to capture >10 woylie individuals per trap session on the low density sites. As a result the grids were subsequently reduced and maintained at 30 traps (5 lines of 6 traps each, i.e. 200 m x 250 m) owing to the resource and logistical constraints and ethical considerations of processing all animals prior to 1100 hrs, particularly on the more abundant sites.

The data collected from captured animals are provided in detail in the WCRP Operations Handbook (Volume 3) but included standard biometric measurements, detailed information on reproductive status and pouch-young development and detailed health checks (Section 5.2 Field health and disease sampling). These trapping sessions were also used to source woylies for radio-collaring as part of the survival and mortality component of the PCS study (Section 4.3). These and other selected animals were also sampled (blood, faeces, ectoparasites and ear tissue) for integrated disease (Chapter 5), resource (Section 4.5) and genetic (Chapter 6) studies.

Capture rates (i.e. trap success) are the proportion (%) of the number of animal captures relative to the number of traps available. Wayne (2006) demonstrated that capture rates were strongly related to more sophisticated population abundance measures, such as minimum number known to be alive (MNA or KTBA) and mark-recapture population models (e.g. POPAN), albeit a more conservative measure of population change. These alternative measures of population abundance will be considered for future analyses, however, during these preliminary explorations of the PCS data, capture rates were used for woylies, koomal and other species (including quenda, chuditch and varanids).

4.2.3. Results

4.2.3.1 Karakamia historical data summary

- Trap success has remained high since 1999, four years after the first translocation.
- Trapping sessions tended to be female-biased in the early days of population establishment (1994 – 1996) and then more commonly male-biased as the population size and density increased (1999 onwards). More recently female-biased sex ratios were recorded in trapping results between September 2006 and May 2007. When only individuals born at Karakamia were taken into consideration, the overall sex ratio of woylies was 453:402 males:females (1.13:1, 53% male), displaying a slighter greater male bias than represented with the captured population.
- Adult woylies were regarded as weighing ≥ 750 g as at this weight many females were carrying pouch young. Some females carried pouch young at a much lower body weight.
- 97% of woylies captured at Karakamia were adults, only 3% subadults < 750 g. It was not possible to draw any conclusions about capture of subadults due to the paucity of these captures.
- Periods of a significant reduction in breeding occurred in January/February 1995 and January 2007. Unfortunately trapping was not conducted in January or February during any other year since 1995 however observations during spotlight walks have suggested that woylies continued to breed over the summer months between 1996 and 2006.
- Body weight of adult woylies was lower at Karakamia than the Upper Warren sites and this occurred right from 1995 when the colony commenced.
- There is some indication that average body weight has declined over time at Karakamia, from around 1170 g in 1995 to 1070 g in 2007.
- All female captures combined over time (1090 g) were slightly heavier on average than males (1075 g).

4.2.3.2. Trapping summary

The number of trap nights remained relatively consistant after an initial period when trapping to apply collars was occurring (Table 4.2.1). The woylie captures varied spatially between PCS trapping grids (Table 4.2.2). The average number of woylie individuals caught on Keninup, Balban, Warrup Boyicup and Winnejup were 28, 8, 17, 2 and 2 respectively. Karakamia caught an average of 43 individuals (Table 4.2.2). The number of individuals caught remained relatively

stable over the study periods at all grids except Balban which experienced a substantial decline over the 12 months.

Table 4.2.1. The number of trap nights for trapping sessions at the WCRP PCS grids.

Session	Keninup	Balban	Warrup	Boyicup	Winnejup	Karakamia
Jul-06	100	100	100	100	100	
Aug-06	75	100	124	194	196	
Sep-06	148	148	148	196	148	196
Oct-06	120	120	120	120	120	
Nov-06						120
Dec-06	120	120	120	120	120	
Jan-07						120
Feb-07	120	120	120	120	120	
Mar-07						90
Apr-07	120	120	120	120	120	
May-07						120
Jun-07	120	120	120	120	120	
Jul-07						90

Table 4.2.2. Trap effort and number of woylie individuals caught for each trap session at WCRP PCS grids.

Session	Keninup	Balban	Warrup	Boyicup	Winnejup	Karakamia
Jul-06	21	11	14	1	2	-
Aug-06	25	12	14	1	3	-
Sep-06	29	10	15	2	6	47
Oct-06	32	13	27	2	2	-
Nov-06	-	-	-	-	-	45
Dec-06	27	7	14	2	1	-
Jan-07	-	-	-	-	-	40
Feb-07	36	4	18	2	1	-
Mar-07	-	-	-	-	-	42
Apr-07	33	5	18	2	2	-
May-07	-	-	-	-	-	44
Jun-07	25	3	13	0	2	-
Jul-07	-	-	-	-	-	42

4.2.3.3. Population abundance

The total capture rates (all species combined) varied considerably between sites: Keninup (46-91%), Balban (32-75%), Warrup (60-77%), Boyicup (13-52%), Winnejup (4-61%), Karakamia (85-93%).

Woylie capture rates were substantially greater than koomal and other species at Keninup (Figure 4.2.1). The capture rates of woylies and koomal were initially similar at Balban but koomal increased substantially in the same period that woylies declined (Figure 4.2.2). The capture rates of woylies and koomal remained similar and relatively stable at Warrup throughout the study period (Figure 4.2.3). Koomal capture rates increased substantially over time while woylie and other captures remained very low at both Boyicup (Figure 4.2.4) and Winnejup (Figure 4.2.5). Woylie capture rates at Karakamia remained at extremely high levels (73-80%) throughout the study while koomal and other species were consistently seldom captured (Figure 4.2.6).

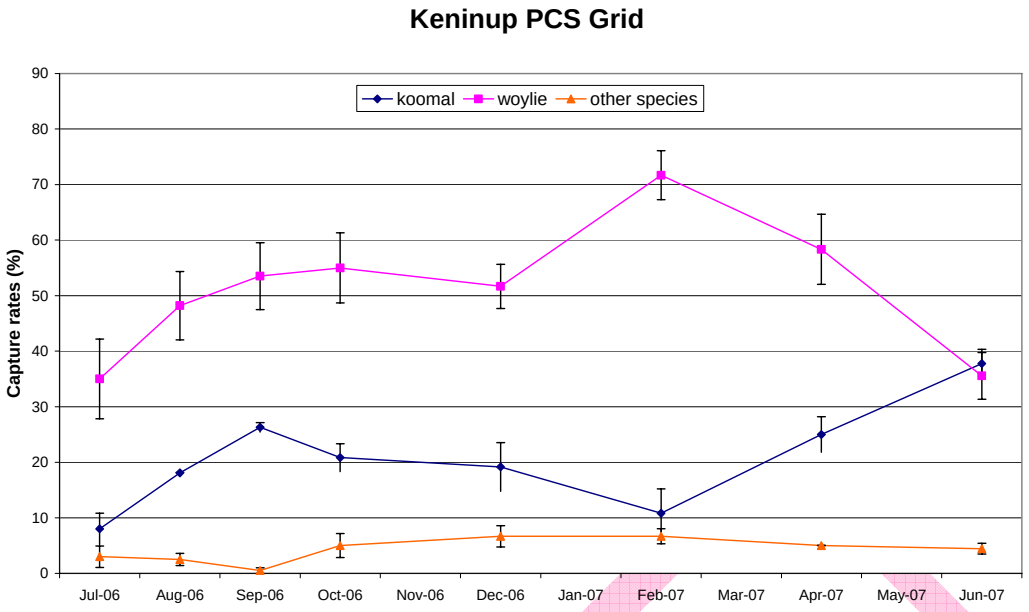

Figure 4.2.1. Capture rate for woylies, koomal and other species at the Keninup Population Comparison Study grid in the Upper Warren region.

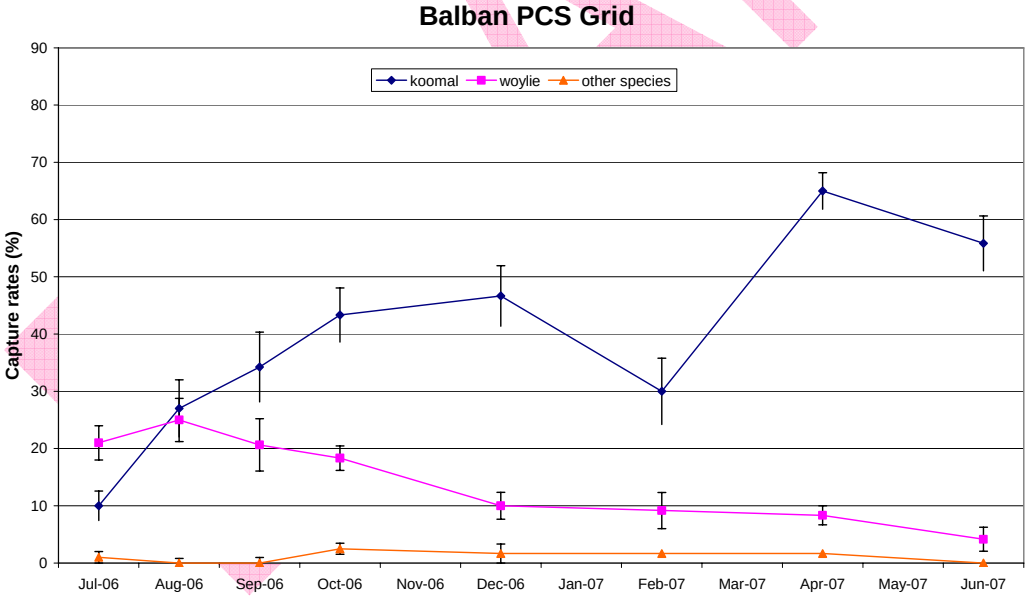

Figure 4.2.2. Capture rate for woylies, koomal and other species at the Balban PCS grid in the Upper Warren region.

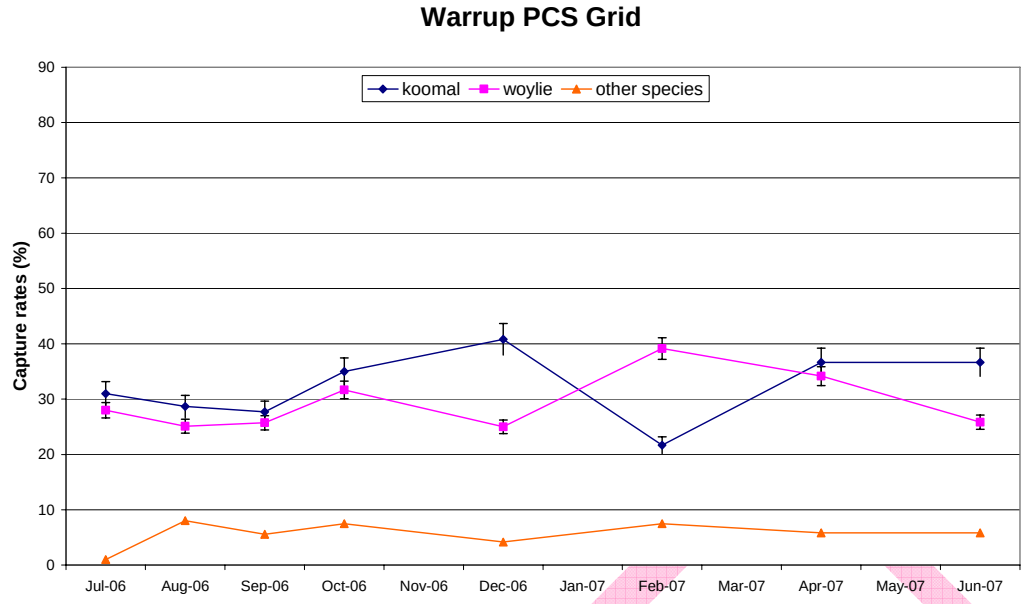

Figure 4.2.3. Capture rate for woylies, koomal and other species at the Warrup PCS grid in the Upper Warren region.

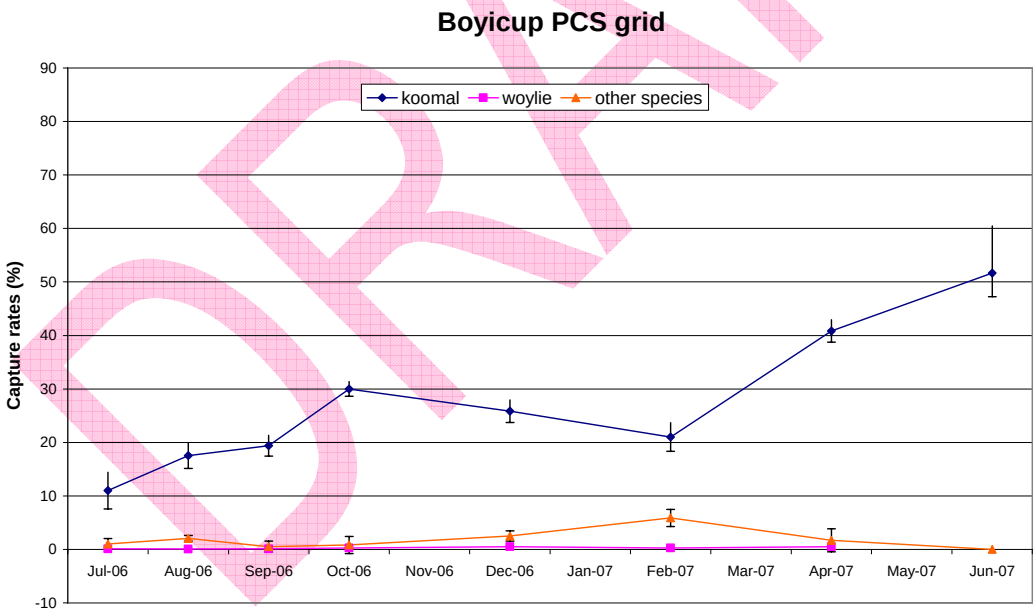

Figure 4.2.4. Capture rate for woylies, koomal and other species at the Boyicup PCS grid in the Upper Warren region.

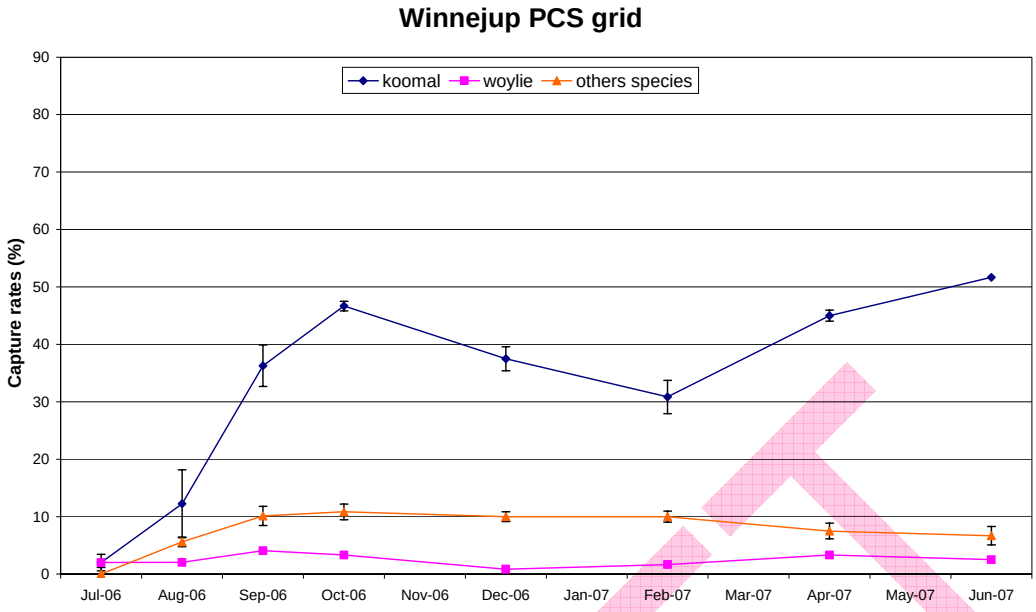

Figure 4.2.5. Capture rate for woylies, koomal and other species at the Winnejup PCS grid in the Upper Warren region.

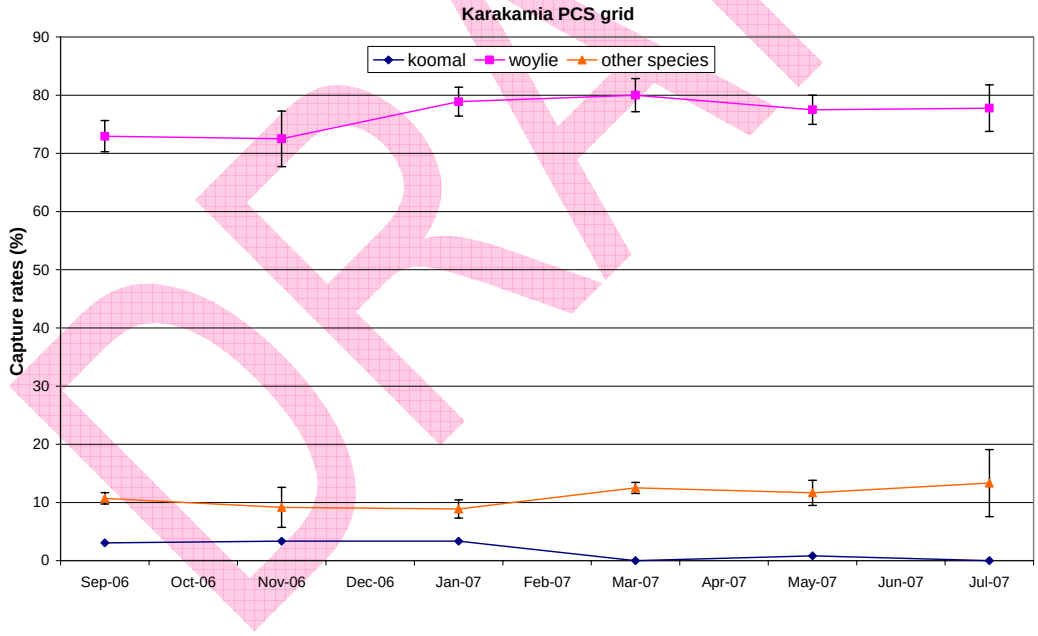

Figure 4.2.6. Capture rate for woylies, koomal and other species at the Karakamia PCS grid in the Upper Warren region.

4.2.3.4. Animal weight

Adult woylies at Karakamia were significantly smaller than Upper Warren sites (means of 1070 g and 1368 g, respectively). Other biometric attributes remain to be examined and compared between PCS sites, including size and animal condition (i.e. a function of size and mass).

The temporal variation in mean weights of woylies for the Karakamia reference grid (Figure 4.2.7) varied slightly, with May 2007 showing a small reduction in the mean weights. There were no significant gender differences in adult weights (female adults mean = 1070 g, range = 1003 g -1113 g; and male adults mean = 1071 g, range = 1005 g -1112 g).

The mean weights of adult woylies for the Upper Warren PCS grids remained relatively stable over time (Figure 4.2.8). Adult females tended to be heavier, although this was not substantial or consistent (female adults mean = 1385 g, range = 1350 g -1437 g; and male adults mean = 1360, range = 1320 g -1395 g).

The mean weights of adult woylies varied between Upper Warren PCS sites (Figure 4.2.9), however caution is required given that repeat measurements of the same individuals have had a disproportionate influence in deriving the mean values for sites with low capture rates (i.e. Boyicup and Winnejup) – this will be addressed in subsequent analyses in which average weights per individual will be used in deriving the mean (i.e. a mean derived from independent measures).

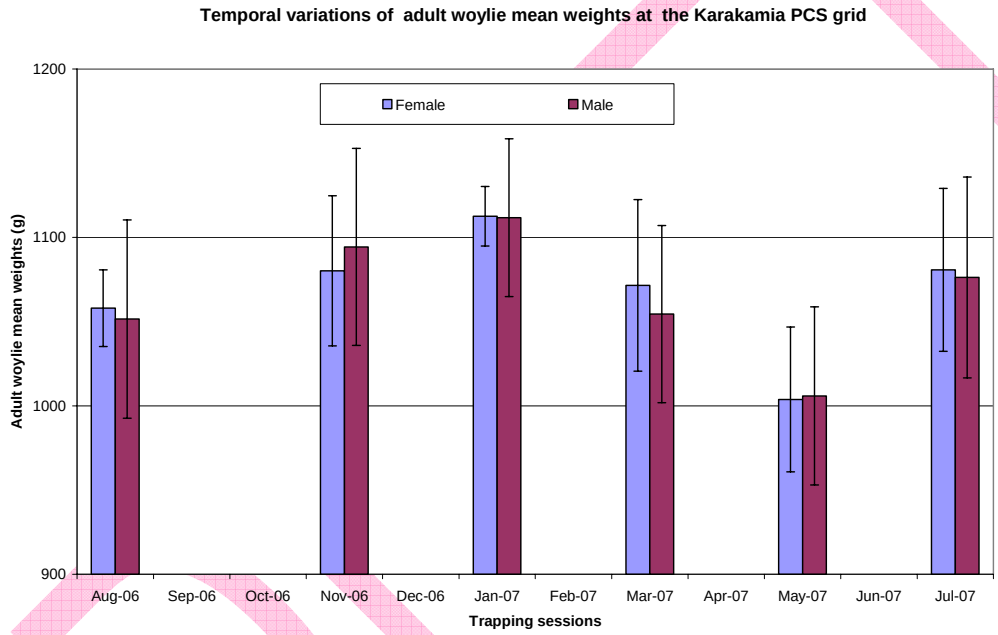

Figure 4.2.7. Temporal variations of adult woylie mean weights at the Karakamia PCS grid

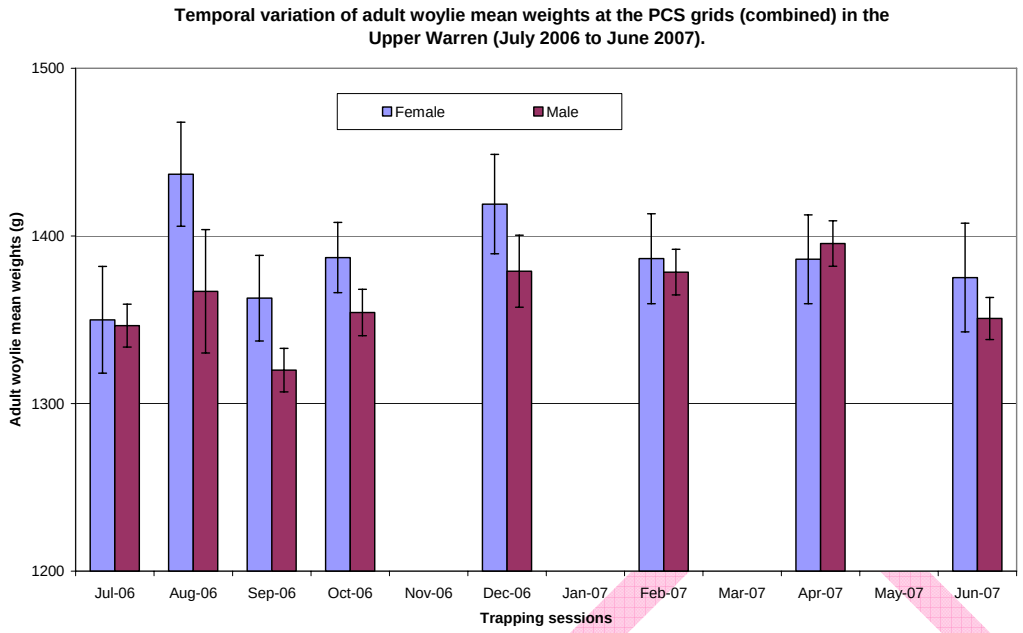

Figure 4.2.8. Temporal variation of adult woylie mean weights at the PCS grids (combined) in the Upper Warren (July 2006 to June 2007).

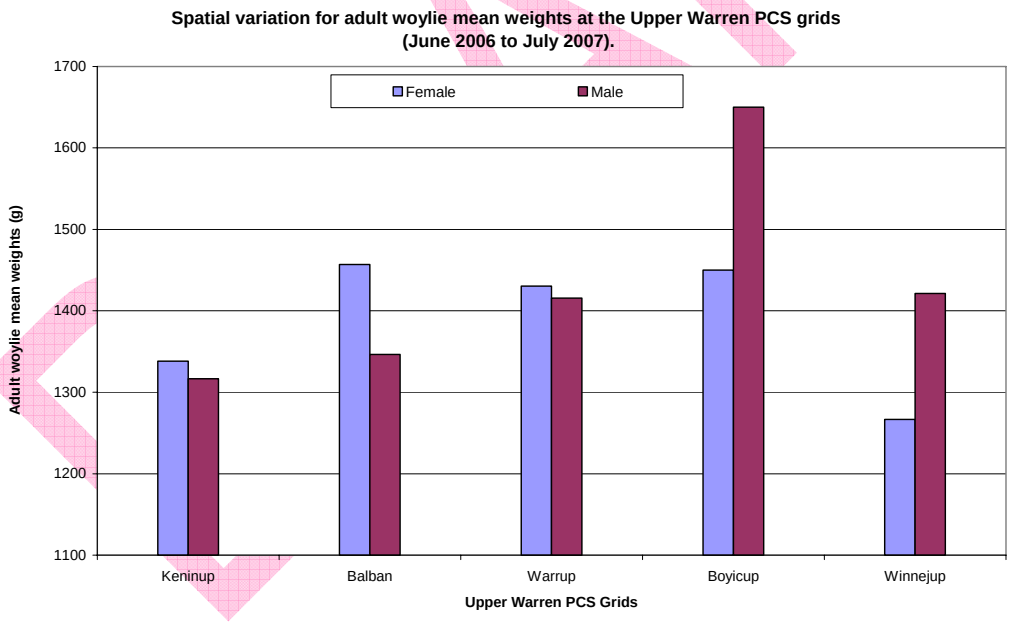

Figure 4.2.9. Spatial variation for adult woylie mean weights at the Upper Warren PCS grids (June 2006 to July 2007).

4.2.3.5. Sex ratio

The ratio of captured adult males to adult females were on average 2.0, 2.7 and 1.6 for Keninup, Balban, Warrup, respectively (Table 4.2.3). This was substantially different from the female bias in Karakamia captures (male/female ratio=0.7; Table 4.2.4). The samples sizes at Boyicup and Winnejup were too small to reasonably assess sex ratios and to compare whether the sex ratios at the 'woylie declined' sites were any different to the more abundant sites where declines had not yet occurred.

Sex ratios generally remained relatively stable over time except where sample sizes were particularly small (Table 4.2.3). The reduction of sample size at Balban over time makes it particularly difficult to confidently determine whether the sex ratio changed in association with woylie declines at this site.

Table 4.2.3. The sex ratio of captured woylies (male/female) at the PCS grids in the Upper Warren.

Grid		Jul-06	Aug-06	Sep-06	Oct-06	Dec-06	Feb-07	Apr-07	Jun-07
Keninup	**Ratio M/F**	2.5	2.6	2.2	1.7	1.5	1.8	1.4	2.1
	n	*21*	*25*	*29*	*32*	*27*	*36*	*33*	*25*
Balban	**Ratio M/F**	2.7	2.0	2.3	1.6	2.5	-	4.0	2.0
	n	*11*	*12*	*10*	*13*	*7*	*4*	*5*	*3*
Warrup	**Ratio M/F**	1.8	1.8	1.5	1.7	1.8	1.6	1.6	0.9
	n	*14*	*14*	*15*	*27*	*14*	*18*	*18*	*13*
Boyicup	**Ratio M/F**	-	-	1.0	1.0	1.0	1.0	1.0	-
	n	*1*	*1*	*2*	*2*	*2*	*2*	*2*	*0*
Winnejup	**Ratio M/F**	1.0	2.0	5.0	-	-	-	-	-
	n	*2*	*3*	*6*	*2*	*1*	*1*	*2*	*2*

Table 4.2.4 The sex ratio of woylies (male/female) for the Karakamia PCS grid.

Grid		Sep-06	Nov-06	Jan-07	Mar-07	May-07	Jul-07
Karakamia	**Ratio M/F**	0.57	0.61	0.74	0.83	0.69	0.62
	n	*47*	*45*	*40*	*42*	*44*	*42*

4.2.3.6. Age demographics

Subadults comprised an average 4.2% (subadult:adult ratio = 0.06) of the independent woylie individuals trapped in any one session at Keninup (Table 4.2.5). Warrup trapped only 2 subadults (February 2007). Balban, Boyicup and Winnejup recorded no subadult captures (Table 4.2.5). Karakamia had an average of 4.6% subadults within the independent woylie population (Table 4.2.6), however, no subadults were captured in January, March or May 2007.

Given the very low incidence rates of captured subadults and the limited sample sizes it is not possible to determine whether there is a statistically significant difference in the age demographics of these populations, in particular whether the absence of subadults at Balban is significantly different from populations that have not undergone decline.

Table 4.2.5. The prevalence of adults, subadults, and juvenile/infants combined, for the PCS grids in the Upper Warren region.

Grid		Jul-06	Aug-06	Sep-06	Oct-06	Dec-06	Feb-07	Apr-07	Jun-07	Ave	SE
Keninup	**Adult**	*21*	*25*	*29*	*32*	*27*	*36*	*33*	*25*	-	-
	Subadult	*1*	*1*	*2*	*2*	*2*	-	*2*	-	-	-
	Juv./Infant	*8*	*8*	*8*	*12*	*13*	*11*	*14*	*8*	-	-
	S:A %	4.5	3.8	6.5	5.9	6.9	0.0	5.7	0.0	**4.17**	**0.01**
Balban	**Adult**	*11*	*12*	*10*	*13*	*7*	*4*	*5*	*3*	-	-
	Subadult	-	-	-	-	-	-	-	-	-	-
	Juv./Infant	*4*	*1*		*5*		*1*	*1*	*1*		
	S:A %	-	-	-	-	-	-	-	-	-	-
Warrup	**Adult**	*14*	*14*	*15*	*27*	*14*	*18*	*18*	*13*		
	Subadult	-	-	-	-	-	*2*		-	-	-
	Juv./Infant	*6*	*2*	*7*	*8*	*1*	*1*	*6*	*5*	-	-
	S:A %	0	0	0	0	0	0.10	0	0	**0.01**	**-**
Boyicup	**Adult**	*1*	*2*	*2*	*2*	*2*	*2*	*2*	-	-	-
	Subadult	-	-	-	-	-	-	-	-	-	-
	Juv./Infant	*0*			*2*	*1*	*1*	*1*	-	-	-
	S:A %	-	-	-	-	-	-	-	-	-	-
Winnejup	**Adult**	*2*	*3*	*6*	*2*	*1*	*1*	*2*	*2*	2.38	-
	Subadult	-	-	-	-	-	-	-	-	-	-
	Juv./Infant	*1*	*1*	*1*	-	-	-	-	-	-	-
	S:A %	-	-	-	-	-	-	-	-	-	-

Table 4.2.6. The prevalence of adults, subadults, and juvenile/infants combined, for the PCS grid at Karakamia

		Sep-06	Nov-06	Jan-07	Mar-07	May-07	Jul-07	Ave	SE
Karakamia	**Adult**	*47*	*45*	*40*	*42*	*44*	*42*		
	Subadult	*6*	*6*				*2*		
	Juv./Infant	*23*	*9*	*1*	*12*	*19*	*23*		
	S:A %	11.3	11.8	0.0	0.0	0.0	4.5	**4.61**	**4.77**

4.2.3.7. Reproduction

The proportion of adult females with pouch-young remained high at all Upper Warren sites (Table 4.2.7). The pouch-young records were absent in some of the Warrup data in particular. The proportion of adult females with pouch-young throughout the study ranged from 76% to 100% (average 89%).

At Karakamia the proportion of adult females with pouch-young varied over time. The proportion was initially high in Spring 2006, and was at its lowest in January 2007 (4%) before increasing through autumn and winter 2007 (Figure 4.2.10).

Table 4.2.7. The presence/absence of pouch-young (PY) with adult female woylies captured at the PCS grids in the Upper Warren region.

		Jul-06	Aug-06	Sep-06	Oct-06	Dec-06	Feb-07	Apr-07	Jun-07
Keninup	**F with PY**	6	6	9	12	11	12	14	8
	F no PY	-	1	-	-	-	1	-	-
	F no record	-	-	-	-	-	-	-	-
Balban	**F with PY**	3	3	2	5	2	2	-	1
	F no PY	-	-	-	-	-	-	-	-
	F no record	-	1	1	-	-	-	-	-
Warrup	**F with PY**	5	3	4	6	2	7	6	5
	F no PY	-	1	-	1	1	-	1	-
	F no record	-	1	1	3	2	-	-	2
Boyicup	**F with PY**	-	-	1	1	1	1	1	-
	F no PY	-	-	-	-	-	-	-	-
	F no record	-	-	-	-	-	-	-	-
Winnejup	**F with PY**	1	1	1	-	-	-	-	-
	F no PY	-	-	-	-	-	-	-	-
	F no record	-	-	-	-	-	-	-	-
Total n	**Females**	**15**	**17**	**19**	**28**	**19**	**23**	**22**	**16**
Total %	**F with PY**	**100%**	**76%**	**89%**	**86%**	**84%**	**96%**	**95%**	**88%**

Table 4.2.8. The presence/absence of pouch-young (PY) with adult female woylies captured at the Karakamia PCS grid

		Sep-06	Nov-06	Jan-07	Mar-07	May-07	Jul-07
Karakamia	**F+ PY**	25	14	1	13	18	23
	F - PY	6	12	22	10	9	6
	F No rec						
Total n	**Females**	**31**	**26**	**23**	**23**	**27**	**29**
Total %	**F with PY**	**81%**	**54%**	**4%**	**57%**	**67%**	**79%**

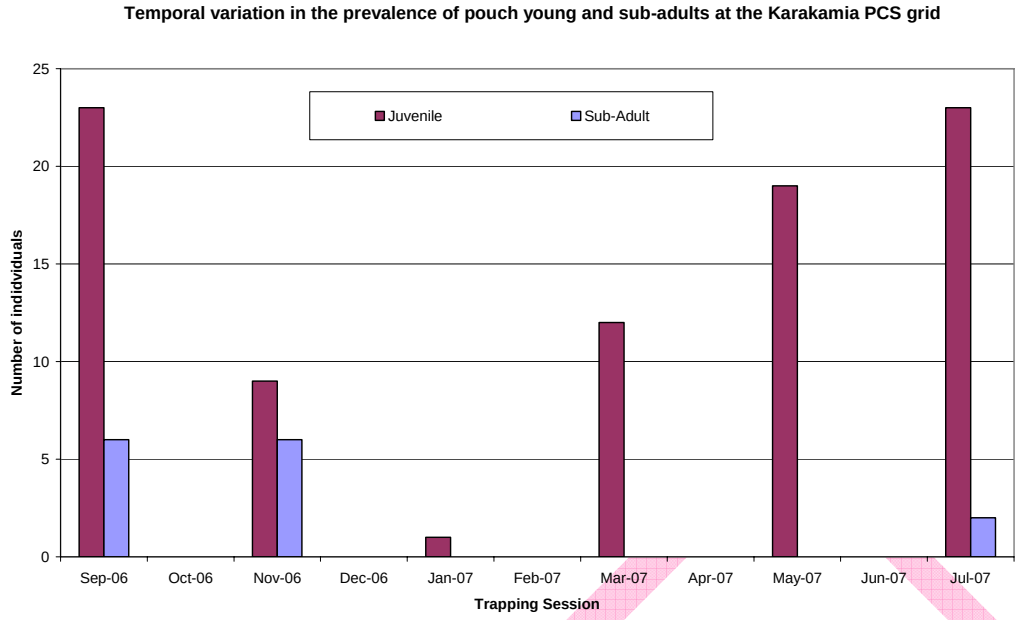

Figure 4.2.10. Temporal variation in the prevalence of pouch-young and subadults at the Karakamia PCS grid.

Pouch-young survival

Juvenile woylies were implanted with Trovan microchips (PIT tags) where possible and appropriate. Only fully furred juveniles (i.e. still dependent on their mother) were implanted for welfare considerations and implanting was only conducted by individuals experienced and trained to do so (i.e. AW, JW, MM and CW). As a result, only three juveniles were implanted and successfully released with their mother at Keninup, two at Balban and one at Warrup. One of these juveniles was subsequently recaptured as an adult at Keninup (not on the grid where originally located but on the transect nearby). An additional two juveniles that were implanted at Keninup and one from Balban were not successfully released at or shortly after implanting and were taken into care.

4.2.4. Discussion

4.2.4.1. Relative woylie abundances

The spatial and temporal patterns in the relative abundances of the woylie derived from the Population Comparison Study (PCS) grids (i.e. site level) were entirely consistent with the trapping data derived from the Upper Warren Fauna Monitoring transects (Chapter 2) and the woylie activity indices using sandpads (Section 4.4 Predators) that were both operating at larger landscape scales (i.e. forest blocks) within the same areas. Of particular note is the 81% decline in the capture rate of woylies at Balban over the 12-month study period. This was in contrast to the relatively stable temporal trends observed at the last remaining moderate density populations in the Upper Warren (Keninup and Warrup), the previously declined and now low density sites of Boyicup and Winnejup and the persistently high density population at Karakamia.

An associative trend between woylies and koomal was also apparent among the PCS sites. Where moderate densities of woylies persisted (i.e. Karakamia, Keninup and Warrup), koomal capture rates were also stable. Where woylies were either declining (Balban) or had previously declined and remained at low densities (Boyicup and Winnejup), koomal capture rates substantially increased between July 2006 and June 2007. This is consistent with observations at Dryandra (Orell, 2004). At the Upper Warren regional scale, the meta-analysis found no significant association between koomal and woylie population changes over time (Chapter 3 Meta-analysis). A definitive verification of whether there exists any association between these species and the

nature of the relationship (i.e. cause or effect), would be useful evidence that would assist the diagnosis of woylie declines.

4.2.4.2. Sex ratio

The substantial differences in the sex ratios observed in the moderate density populations in the Upper Warren (male biased) compared with the high density population at Karakamia (female biased) is particularly striking. It is not possible to reasonably infer directly from trap capture data what the *actual* sex ratio within a population may be because of the gender biases in trappability and the influences that trapping methodology has on these biases (Wayne *et al.,* in press). The identical trapping methodology between the PCS grids eliminates any influence that this may have on the sex ratio of captured individuals, however, the extent to which differences in animal density may confound direct comparability between sites is unknown. Despite these constraints, it is remains likely that real and substantial differences exist between Karakamia and the Upper Warren moderate density populations.

No temporal changes in the sex ratio were detected as the Balban population declined. However, the small sample sizes fundamentally limited the ability to confidently detect anything but the most dramatic of changes (i.e. poor statistical power *e.g.* Taylor and Gerrodette, 1999). Similarly the same inherent problem arises when attempting to compare the 'declined', low density populations with the moderate density sites. These limitations are common to all of the demographic attributes examined here, and are symptomatic of the challenges to generate sufficient data for statistical inference from animals that may be rarely encountered and/or become increasingly so over time (e.g. Caughley, 1994; Caughley and Gunn, 1996).

4.2.4.3. Recruitment potential – prevalence of pouch-young and subadults

The high proportion of adult females encountered with pouch-young (i.e. average of 89% in the Upper Warren and 57% in Karakamia) was consistent with earlier findings (89% in Perup; Christensen, 1980). Not withstanding the interpretive constraints of small sample sizes (already discussed) it is likely that reproductive rates remained consistently high among adult females at the Upper Warren PCS grids (i.e. including declining and declined populations). This was different to Karakamia, which varied substantially over time. The temporal variation in the prevalence of subadults in the Karakamia woylie captures is consistent with a temporal lag in the presence of pouch-young. Data from multiple years would be required to verify that this temporal variation is a likely seasonal breeding pattern (i.e. reduced or no breeding in the hotter/drier months). This contrasts the apparent aseasonal breeding within the Upper Warren region, which is consistent with previous research in the area (Christensen, 1980; Wayne unpublished data).

The three principle factors that may account for the low prevalence of subadults in a captured population include;

- The relatively short time that independent individuals remain sexually immature (i.e. subadult woylie for 30-60 days) compared with the time spent in the pouch (100-110 days) and normal life expectancy (5-6 years) (Christensen, 1980; Seebeck and Rose, 1989) (i.e. relates to probability of capture within a short time period)
- differential mortality rates of subadults, and
- possible trappability differences

High mortality rates of woylies around the age of independence is a likely significant contributor to the low prevalence of subadults, however, more sophisticated analyses and population modeling are required to quantify the relative mortality rates of woylie life stages. Nonetheless, the observations in this study are at least broadly consistent with previous research of woylies in the Upper Warren which found that pouch-young survival was relatively high (82-91%) but low after pouch emergence with only 11-15% of young surviving through to adulthood (Christensen, 1980).

No subadults were detected within the declining woylie population at Balban (despite moderate prevalences of infants and juveniles), or at the two declined populations at Boyicup and Winnejup. Similarly, Warrup recorded only two subadults. Determining whether there has been a reduction in the prevalence of subadults associated with the woylie declines is not possible using the PCS dataset alone, given the limitations of the data (small number of animals captured and low prevalence rates of subadults). Pooling of the PCS data with compatible monitoring data may however, provide enough data to examine whether there are any differences in the prevalence and potential recruitment rate of immature animals associated with the declines.

Challenges associated with measuring juvenile recruitment and survival has limited that ability to look at this potentially important component of demographics in more detail. The sample sizes obtained in this study of fully-furred juveniles suitable for PIT implants were insufficient for statistical inference. Substantially greater trapping effort (frequency and extent) to increase sample sizes would be required to overcome this at the moderate-density PCS sites, even more so for the low-density sites. Subsequent surveys would need to be sufficiently extensive to account to some extent for the dispersal of subadults away from their natal range. The use of radio-telemetry (usually via neck collars or tail fixtures) is also limited by the capacity to accommodate rapid growth of juveniles and subadults, but does more readily overcome issues associated with tracking the fate of dispersing animals. A third complementary or alternative approach may indirectly infer the survival or recruitment rate by comparing the relative prevalence of pouch-young, juveniles, subadults and new adults. Having considered the necessary assumptions (e.g. differences in capture probabilities), the differences in the prevalence rates can be used to derive an estimate of survival. This remains to be fully explored with the data currently available.

4.2.5. Future work

The main priority for the PCS investigation in woylie demographics is to develop and complete the data analysis in preparation for publication in a peer-reviewed paper. This will include;

- Complete more rigorous analyses of the demographic attributes initially explored and discussed in this report
- Analyse the biometric data to investigate demographic differences in animal size, weight, condition, etc over space and time, and in relation to woylie declines
- Analyse the trap capture data to investigate population differences in population turnover and recruitment (i.e. incidence of new animals over space and time)

The field work associated with the PCS of woylie demographics ceased (indefinitely) in June 2007. The continuation or development of further demographic research will be reviewed as part of the greater review of the Woylie Conservation Research Project.

- The vegetation assessment of PCS trapping sites for the purposes of density and demographic comparisons and relatedness of data is still to be completed.

4.2.6. Conclusion

Some of the key preliminary results from an initial exploration of the demographic data include;

- Balban underwent an 81% decline in woylie capture rates in the 12 months from June 2006. Capture rates at all of the PCS grids were consistent with other woylie data sets.
- Koomal capture rates increased at grids where woylies declined (Balban) or had previously declined (Boyicup and Winnejup) and remained relatively stable at the stable moderate-high woylie density grids (Karakamia, Keninup, Warrup).
- Small sample sizes from low density and declining populations inherently limits the power of statistical inference to determine if there are significant differences in the demographic attributes between woylie populations at various stages of decline. This emphasizes the importance of having sufficient resources available to support the increased effort required to collect sufficient data for analysis.
- There is no evidence that there are substantial changes in reproduction associated with Upper Warren woylie declines (inferred from prevalence of pouch-young).
- It remains uncertain whether the survival of offspring through to independence (subadult) and sexual maturity (adult) differs in association with woylie declines.
- The Karakamia woylie population in recent times is remarkably different on a number of accounts including, especially high woylie densities, female bias in sex ratio of captured individuals, likely seasonal breeding, and substantially smaller mean weights of adult males and females.
- More formal and thorough analyses are required before evidence from the demographics of woylies can be used to confidently investigate for clues as to the mechanics and possible causes of decline.

4.2.7. References

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