Sus scrofa: Population Structure, Reproduction and Condition in Tropical North-Eastern Australia

Peter M. HEISE-PAVLOV[a*] – Sigrid R. HEISE-PAVLOV[a] – John E. NELSON[b]

[a] PavEcol Wildlife Management. Queensland, Australia
[b] Department of Evolutionary Biology, Monash University, Melbourne. Australia

Abstract – Three feral pig populations inhabiting contrasting environments along the north eastern coast of Australia have been investigated with respect to population structure, individual condition and reproduction. The population on Prince of Wales Island contains a large proportion of juvenile and sub-adult pigs but lacks pigs in the higher age classes. Individuals also breed at an earlier age than animals of the mainland populations. Pig populations on Cape York Peninsula show a larger proportion of older animals and feral pigs living in rainforest habitats show a low proportion of animals in very young and very old age classes. Pigs from the lowland rainforest population are in better condition than those of the other populations for most of the year, reflecting the availability of food all year round in this environment. Differences in the population structure of the three populations are discussed with respect to fecundity and several mortality factors such as predation and diseases/parasites.

pigs / age structure / breeding / condition index

Kivonat – A vaddisznó-populáció szerkezete, szaporodása és kondíciója a trópusi északkelet Ausztráliában. Három, Ausztrália északkeleti partvidékén vadon élő vaddisznó populációt vizsgáltunk a populáció struktúrája, az egyedek kondíciója és reprodukciója szempontjából. A Wales herceg-szigeti populációban legnagyobb arányban a fiatalok és a szubadult vaddisznók vannak jelen, az idősebb korosztályokból hiányoznak a vaddisznók. Az egyedek itt korábban szaporodnak, mint a kontinens állatai. A Cape York-félsziget populációja, amely az esőerdei élőhelyen él, az idősebb egyedek nagyobb arányát mutatja, kis arányát mutatja azonban a nagyon fiatal és a nagyon öreg korosztályoknak. Az alföldi esőerdők vaddisznó populációi az év nagy részében jobb kondícióban vannak, mint a többi populáció, jól mutatva a táplálék egész évi hozzáférhetőségét közvetlen környezetükben. A tanulmány megvitatja a három populáció szerkezetének különbségét a születési arányszám, valamint a különböző halálozási tényezők, a ragadozás és a betegségek/paraziták figyelembe vételével.

vaddisznó / korszerkezet / szaporodás / kondíció index

[*] Corresponding author: alectura@bigpond.com; 211 Turpentine Road, Diwan via Mossman. 4873. Queensland, Australia

1 INTRODUCTION

Amongst the ungulates, the wild boar (*Sus scrofa*) is one of the most adaptable species. (Dexter 1990, Choquenot 1998). They have the highest potential reproductive rate of any ungulate, potentially breeding all year round with two litters per female (Barrett 1978). In combination with a low impact of predators, this may result in high population densities when conditions are optimal (Taylor et al. 1998). Population growth rates of 0.78 have been reported and are amongst the highest for an ungulate species (Mauget et al. 1984, Giles 1980). Detailed studies on population dynamics of feral pigs have been conducted in various areas of Australia, such as in the semi-arid rangelands (Giles 1980, Choquenot 1994), subalpine areas (Saunders 1988, 1993), tropical woodlands and floodplains (Corbett 1995) and tropical rainforest (Pavlov – Edwards 1995, Mitchell 2001).

These studies suggest that food availability is the most obvious factor determining the growth of pig populations in seasonally dry habitats of Australia. Additionally, predation by dingoes and the impact of diseases and parasites have been identified as factors affecting pig populations in the wet-dry tropics of Australia (Corbett 1995, Heise-Pavlov – Heise-Pavlov 2004). However, comparative studies on feral pig populations in north eastern Australia are few in number, but essential for better management of this pest species.

This study focuses on the analysis of population structure, the condition of animals, the average litter size and the age of first reproduction of females in feral pig populations living in three different habitats in NE Australia which differ in respect to seasonality, food availability and predation. Comparing pigs on an island with strong seasonal variation in food, a seasonally dry woodland habitat and a lowland rainforest habitat with low seasonal variability and an abundance of food, we would expect pigs from the rainforest habitat to be in better condition and have larger litters than those from the other contrasting habitats examined.

2 MATERIALS AND METHODS

2.1 Study areas

The three studied populations are located in areas of north Queensland above 16 degrees 12 minutes of Latitude South *(Figure 1)*. The areas differ regarding the duration and intensity of dry and wet seasons which can be expressed by a seasonality index (SI), developed by Walsh - Lawler (1981). SI is the sum of absolute deviations of mean monthly rainfall from the overall monthly mean, divided by the long term mean annual rainfall.

The first population of feral pigs was studied on Prince of Wales Island (in text POW) at 142°12’E and 10°40’S. It is a 50km² Island, 30 kilometres north of the mainland of Australia. The island has a tropical monsoon climate with 3-4 months of rain followed by 8-9 months of dry weather. The average annual rainfall is 1,800 mm. The vegetation is dominated by savanna eucalypt woodland (*Eucalyptus tetradonta*) on well drained soils, patches of Blady grass (*Imperta cylindrical var. major*), patches of Paperbark (*Melaleuca viridiflora*) on poorly drained soils and occasional outcrops of mixed vine forest on rocky slopes.

The second population of feral pigs was sampled on Cape York Peninsula (in text CY) (a rough triangle shape, with the tip 142°33’E 10° 42’S, the south western corner 141°25’E, 16°12’S and the south eastern corner 145°24’E, 16° 12’S) approximately 126,000km² in area. CY Peninsula has a tropical monsoon climate similar to POW Island with the amount and timing of the rain being variable. Rainfall varies between 700mm and 1,800 mm per year. There are many permanent streams and lagoons. The watercourses flowing east are less than 120 kilometres long, while the streams flowing west, across eroded floodplains, are up to 300km long. The vegetation is varied with the most widespread communities being Open

Savanna Woodland (dominated by *Eucalyptus tetradonta* and *E. sp. aff. polycarpa* with a range of grasses in the understory), Gallery Forest (strips of forest occurring along all significant drainage lines with dominant *Ficus spp.*, *Parinari nonda*, *Nauclea orientalis* and the introduced mango *Mangifera indica*) and Grassland (dominant grass species are: *Dichanthium sp*., *Panicum maximum*).

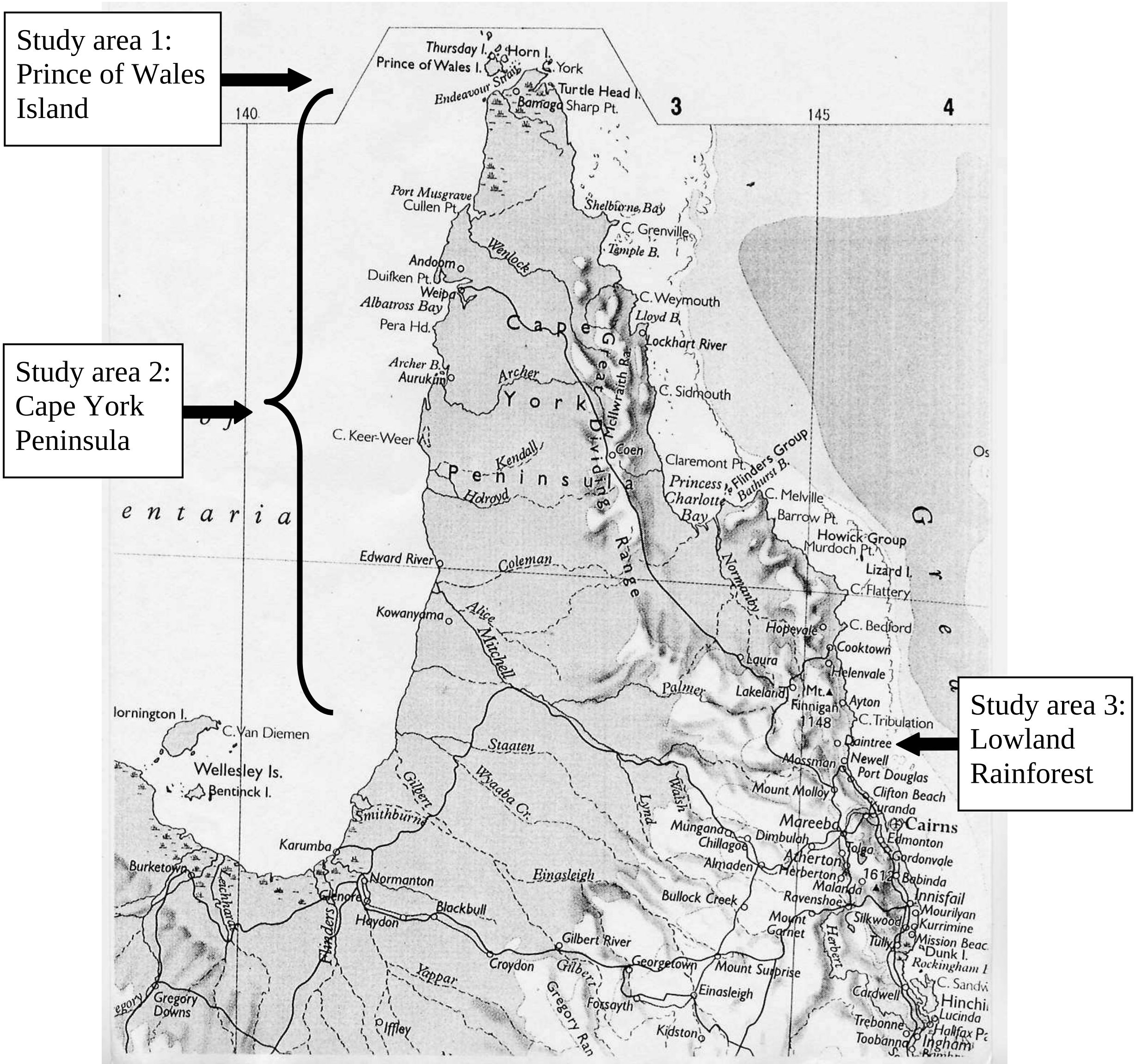

Figure 1. Study sites

The third feral pig population studied was sampled in the wet tropical lowland rainforest (in text LR) at 145°25’E 16°5’S. It has an area of 400 km². Coastal ranges with peaks up to 1,300 metres, at right angles to the prevailing south east wind, produces orographic winter rainfall as well as monsoonal summer rains, totalling an average of 3.5 metres of rain per year. The vegetation is primarily complex vine forest (1A) and mesophyll vine forest (2A, 2B) (Tracey 1982) with up to 150 vascular species per hectare. Permanent streams are common and usually short (less than 10 kilometres long). High humidity persists all year round in this environment.

2.2 Sampling methods

Pigs were mainly shot after hunting on foot with dogs (CY), or from a vehicle (POW). In the LR many pigs were caught in welded mesh traps incorporating a spring-loaded gate with the trigger mechanism consisting of a horizontal bar. The bar would be lifted when the animal fed on the supplied food and the door would snap shut. Pigs were killed by a head-shot according to the guidelines "Model Code of Practice for the Welfare of Animals" (SCA Technical Report Series, No. 34 1996). 351 pigs were sampled from 1982 to 1985 from Prince of Wales Island, 470 pigs were sampled from 1981 to 1986 from Cape York Peninsular and 337 pigs were sampled between 1992 and 2000 from the lowland rainforest site.

2.3 Population structure

The age of caught pigs was assessed by a modified classification of tooth eruption (Matschke 1968) up to an age of 26 months. For ages between 26 and 72 months ages were assessed on tooth wear and loss (modified by Barrett 1978). There is a progressive tooth eruption until 36 months of age and a generalised wear pattern (related to abrasiveness of the food) of the molars until 72 months. This is a simplified ageing method, but in the absence of knowledge of wear patterns on wild animals (from specific areas), no further precision can be attained. The following age classes have been used: 1 (0-5.5 months), 2 (6-12.5 months), 3 (13-24.5 months), 4 (25-36.5 months), 5 (37-48.5 months), 6 (49-60.5 months), 7 (61-72.5 months) and 8 (> 73 months). The number of animals per age class was compared by x^2test between the populations.

2.4 Individual condition

In order to assess the condition of animals, the weight of its mesogastric fat (StoFat) was related to the weight of the carcase (Gutted Weight = GW) by using the following formula describing a condition index [CondInd = (StoFat/GW) x 1000]. Mesogastric fat is associated with the 'net' of blood vessels on the outer circumference of the stomach. This structure can be easily dissected away from the stomach and weighed. Gutted weights were used to standardise carcase measurements of the sows without having pregnant sows and their attendant embryos confounding the measurement. In order to minimise the effects of seasonality, the CondInd was compared between the populations based on available data collected at the same time of the year. Therefore monthly average CondInd were compared between CY and LR using the Mann Whitney U-test for the months January to June and September and December while the Kruskal Wallis test was applied to compare the monthly average CondInd for the months July, August, October and November between all three populations (Fowler – Cohen 1990). This was necessary as sampling on POW occurred only in the months July/August and October/November.

2.5 Reproduction

Females were classified as pregnant/lactating according to the presence of foeti in the uterus and the presence of active teats respectively. Sows classified as early pregnant, had foeti less than 20mm long. The average litter size was calculated based on the number of active teats (expressing milk).

The mean gutted weight and mean age of reproducing females were compared between the three populations by the Kruskal Wallis test with subsequent significant tests for multiple comparisons (see Siegel – Castellan 1988). The age of the youngest reproducing female was determined for each population.

3 RESULTS

The three investigated populations live in habitats which differ in the duration and intensity of dry and wet seasons. While the habitats of populations on CY and POW show a similar seasonality index of 1.137 and 1.127, indicating a high seasonality, the population in the LR lives in a less seasonal climate but is still characterised by distinct wet and dry seasons, with a seasonality index of 0.676.

3.1 Population structure

The distribution of sampled pigs into the above mentioned age classes showed a younger population on POW *(Table 1 and Figure 2)* with significantly more individuals at age class 1 and 2 than the CY and LR populations. An older population was recorded on CY with significantly more individuals belonging to age class 7 and 8 than in the other sampling sites. The pig population on LR were the most evenly distributed per age class.

Table 1. Comparisons of age classes between sampled pig populations of Cape York Peninsular, Prince of Wales Island and Lowland Rainforest – results of X^2 Tests

age class	$CY_1 – LR_2$		$CY_1 – POW_3$		$LR_2 – POW_3$	
1	$n_1 = 8$ $X^2 = 24.92$	$n_2 = 44$ $p < 0.000$	$n_1 = 8$ $X^2 = 152.39$	$n_3 = 175$ $p < 0.000$	$n_2 = 44$ $X^2 = 78.36$	$n_3 = 175$ $p < 0.000$
2	$n_1 = 28$ $X^2 = 24.30$	$n_2 = 79$ $p < 0.000$	$n_1 = 28$ $X^2 = 10.46$	$n_3 = 58$ $p < 0.001$	$n_2 = 79$ $X^2 = 3.21$	$n_3 = 58$ $p < 0.073$
3	$n_1 = 29$ $X^2 = 3.45$	$n_2 = 45$ $p < 0.063$	$n_1 = 29$ $X^2 = 5.12$	$n_3 = 49$ $p < 0.024$	$n_2 = 45$ $X^2 = 0.17$	$n_3 = 49$ $p < 0.68$
4	$n_1 = 155$ $X^2 = 53.78$	$n_2 = 50$ $p < 0.000$	$n_1 = 155$ $X^2 = 82.66$	$n_3 = 31$ $p < 0.000$	$n_2 = 50$ $X^2 = 4.45$	$n_3 = 31$ $p < 0.035$
5	$n_1 = 82$ $X^2 = 10.12$	$n_2 = 46$ $p < 0.001$	$n_1 = 82$ $X^2 = 56.34$	$n_3 = 10$ $p < 0.000$	$n_2 = 46$ $X^2 = 23.14$	$n_3 = 10$ $p < 0.000$
6	$n_1 = 105$ $X^2 = 35.00$	$n_2 = 35$ $p < 0.000$	$n_1 = 105$ $X^2 = 67.50$	$n_3 = 15$ $p < 0.000$	$n_2 = 35$ $X^2 = 8.00$	$n_3 = 15$ $p < 0.005$
7	$n_1 = 57$ $X^2 = 5.26$	$n_2 = 35$ $p < 0.022$	$n_1 = 57$ $X^2 = 34.90$	$n_3 = 9$ $p < 0.000$	$n_2 = 35$ $X^2 = 15.36$	$n_3 = 9$ $p < 0.000$

3.2 Individual condition

In July, animals on POW show significantly higher CondInd than those on CY ($p < 0.01$) and from the LR ($p < 0.01$). For the months January, April and June, animals from the LR show a significant higher CondInd than those from CY *(Figure 3)* ($p < 0.01$ for January and April, $p < 0.05$ for June). In September, the CondInd is significant higher in animals of CY than in the LR ($p < 0.001$). In November, animals of the LR show significantly higher CondInd than those from CY and POW (both $p < 0.05$).

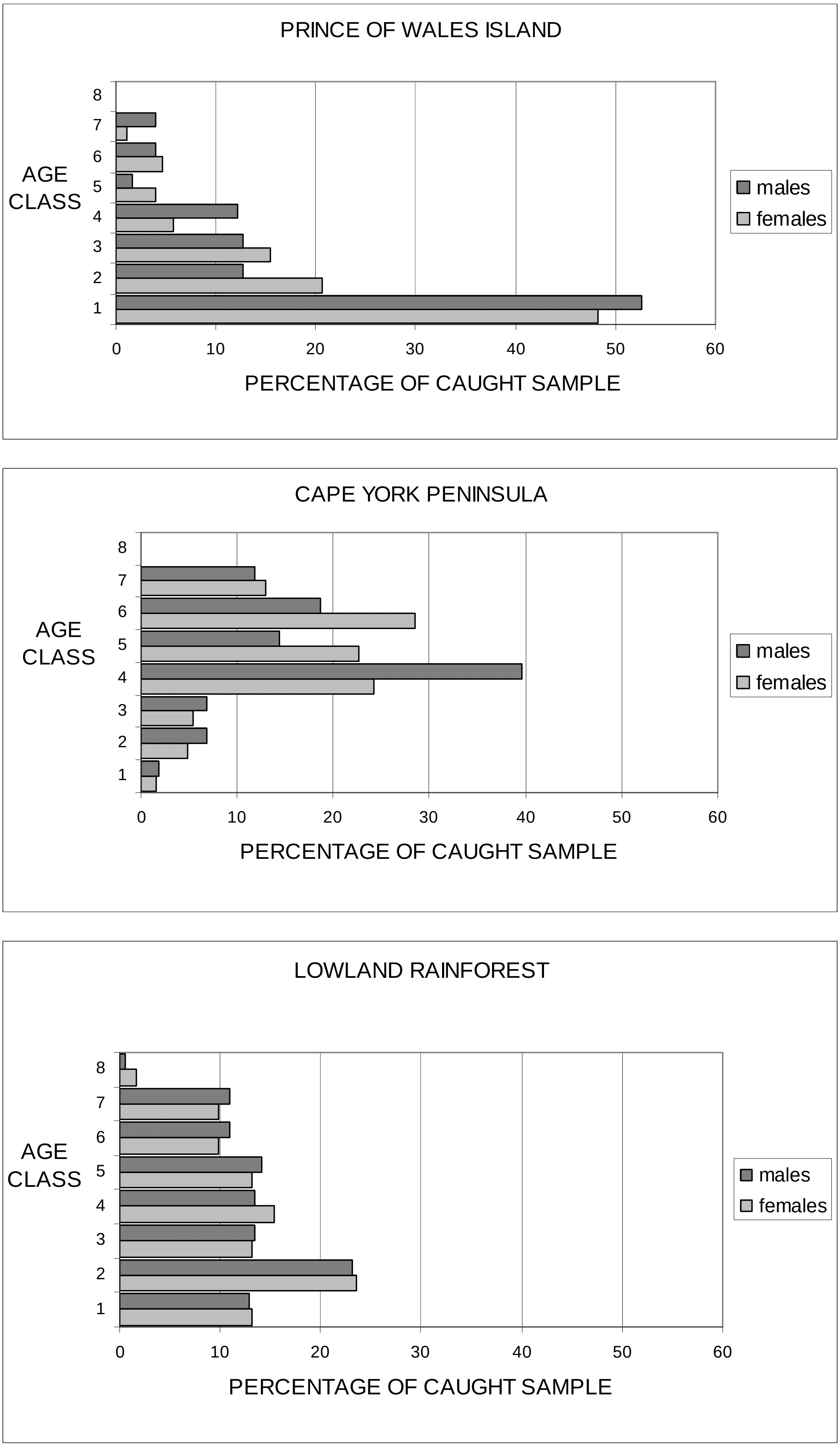

Figure 2. Population structures of three feral pig populations in tropical northern Australia

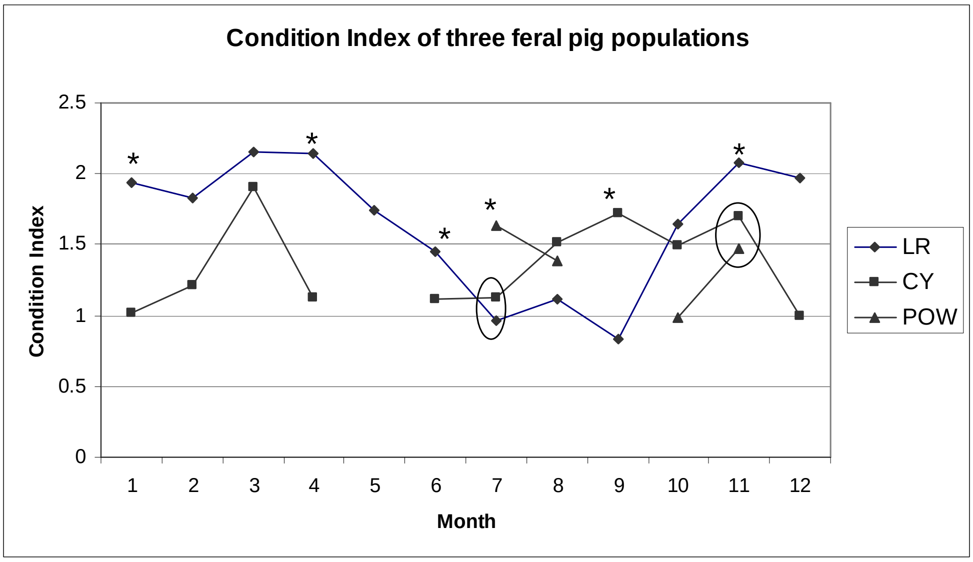

Figure 3. Condition Index of feral pigs from three different populations in tropical northern Australia

3.3 Reproduction

The average gutted weight of reproducing females was significantly lower in the POW population compared to CY and LR populations (mean GW POW: 16.03 kg ±1.18, CY 37.96 kg ± 1.13, LR 37.83 kg ± 2.29; Kruskal Wallis test: $X^2 = 53.11$, $p < 0.000$) *(Figure 4)*. Females in the POW and LR populations reproduce at an earlier age compared to females on CY (mean age of reproducing females: POW: 21.91 months ± 2.52, CY 47.76 months ± 1.76, LR 24.56 months ± 2.98; Kruskal Wallis test: $X^2 = 51.87$, $p < 0.000$). For the population in the LR, an average litter size of 5.11 ± 0.46, for CY of 6.60 ± 0.59 and POW of 4.25 ± 0.272 have been calculated. On POW, the youngest reproducing female was found at an age of 7 months while the youngest reproducing female on CY was at an age of 12 months. In the LR, the youngest reproducing female was found at an age of 6 months.

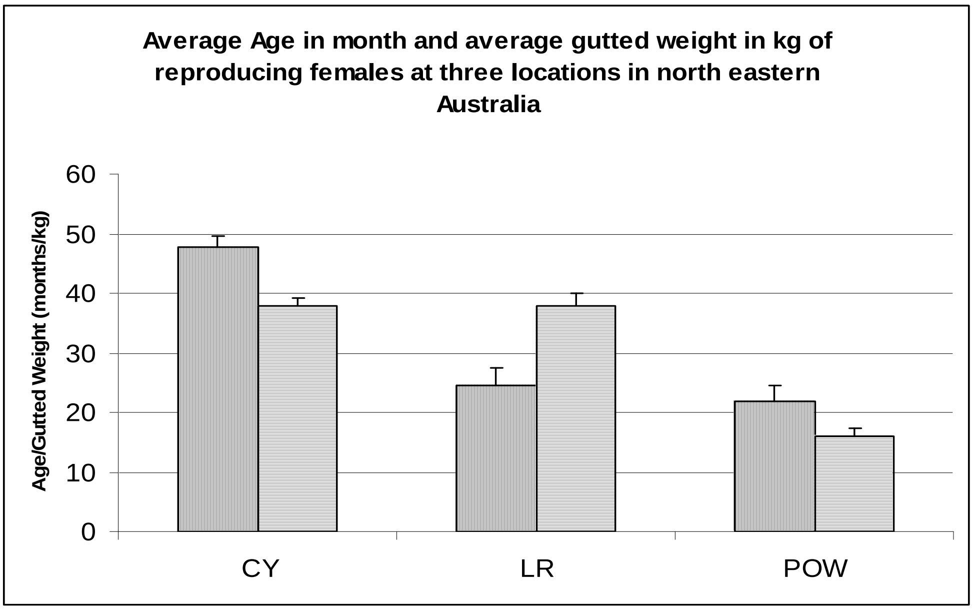

Figure 4. Average age and gutted weight of reproducing females of three feral pig populations in tropical northern Australia

4 DISCUSSION

The three populations of feral pigs occupy habitats that differ climatically and floristically. This high variability indicates that pigs are highly adaptable and are able to use a wide range of food sources (Giles 1980). Populations on Prince of Wales Island (POW) and Cape York Peninsula (CY) live in areas with markedly seasonal rainfall that is reflected by the seasonality index of 1.127 and 1.137 respectively (Walsh – Lawler 1981). Both areas have a humid tropical climate with a distinct wet season between December and March (that is connected with the monsoonal trough over northern Australia creating large flood plains) and a long dry season extending over the other 8 months causing a food shortage for pigs. In contrast, lowland Rainforest (LR) is characterized by a seasonality index of 0.676 indicating a low seasonality (seasonality indices with values less than 0.4 indicate an equal distribution of rainfall, Walsh – Lawler 1981). As on POW and CY, the climate shows a distinct wet season between December and March, but only a short dry season (October) leading to a more sufficient food supply all year round. This was reflected in LR pigs having better condition than those caught on CY or on POW, for most of the year. This indicates that more food is available in the LR habitat than in the other two sites. CY pigs showed a significantly higher condition index in September compared to the LR sample. In September, pigs were caught on CY in the northern part, mainly in riverine habitats that still provide protein rich food in the form of fruit and litter dwelling insects at this time of the year.

The generally higher condition index of animals in the LR habitat enables them to use their high potential reproductive rate in this environment. Although having a higher condition index in the LR population, females of this population do not show a significantly higher litter size compared to the population on CY. However, females on POW have the lowest litter size with 4.25, compared to the populations on either CY or LR. This suggests that the availability of food along the gallery forests in CY allows the sows to fulfil their reproductive potential in the dry season when food is otherwise limited in monsoon woodlands. The high litter size on CY does not reflect the population structure analysis and is likely to be a consequence of dingo predation (Pavlov 1991). In contrast, the high proportion of piglets in the POW population can be attributed to a lower mortality of piglets due to the absence of dingoes on the island. The presence of the dingo on CY may cause a high juvenile mortality in this feral pig population. Piglet survival appeared to be influenced by the activity of dingoes in south-eastern Australia (Newsome et al. 1983). Pavlov (1991) observed dingo predation on CY peninsula. Dingoes are also present in the rainforest, but in low numbers due to the presence of bandicoots in the area carrying the paralysis tick (*Ioxides holocyclus*), which is fatal to dogs limiting their effect on the survival of piglets in this environment. Therefore, factors other than predation must act in the rainforest habitat leading to a lower survival of piglets than on POW and also results in a relatively low proportion of pigs belonging to younger age classes in the LR population. Mitchell (2001) calculated a juvenile mortality of 51% in his study of feral pigs in the wet tropics where he found a high proportion of juvenile and sub-adult pigs. Higher mortality rates of piglets in the LR may be attributable to the presence of external and internal parasites and diseases (Heise-Pavlov - Heise-Pavlov 2003). Although the average litter size was calculated as 5.1 for this environment (Mitchell 2001) gives an average litter size of 6.4), lactating sows are rarely seen with more than 4 piglets in LR. Rates of intrauterine mortality are currently being investigated for this population, but are likely to be high due to the impact of high infection rates of leptospirosis amongst these pigs. Leptospirosis infections in pigs are known to cause abortions, stillbirths and neonatal disease in piglets (Leman et al. 1981). A survey of Leptospirosis infection in each population indicated a 2% infection rate on POW, 7% infection rate on CY (Pavlov 1991) and an infection rate between 52% and 58% in the LR population with 10 different serotypes represented and up to 4 serovars (strains) per pig (Heise-Pavlov - Heise-Pavlov 2004). The higher prevalence of diseases and parasites in the LR population may also affect adult mortality. Fewer pigs over 50 months of age have been caught in the LR than on CY and POW. The adult mortality on CY seems to be lower than on POW. Both sites show a similar climate with a prolonged dry season and a short wet season. However, the variety of habitats and places of permanent water supply on CY may reduce mortality of older pigs. The older population on CY leads to an older mean age of breeding females in this population (47 months), compared to the other two investigated populations (21-24 months of age).

The high proportion of pigs up to 12 months of age in the POW population can also be due to the onset of breeding at an earlier age. Our study shows that females on POW contribute to breeding at a younger age than those of the CY population. Females in the LR and POW populations start breeding at an age of 6 to 8 months. The reduced age of sexual maturity and reproduction of animals on islands is often attributed to an accelerated growth potential (Sondaar 1977) and will be investigated in more detail for the POW population.

The study shows that feral pig populations in northern Australia have adapted to various food sources in contrasting environments and their potentially high reproductive output is affected by predation and diseases/parasites resulting in different age structures of the populations. The management of susceptible feral pig populations along the “top end” of Australia is essential and requires more detailed studies on the dynamics of these populations.

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