

## Growth of feral pigs in New Zealand

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For 2,674 pigs date and location of kill, sex, field-dressed weight, body length, length, height and condyle height of the mandible were determined. Their age was assessed from (a) tooth replacement and wear and (b) cementum layering in molars. Males were consistently heavier than females from birth onwards, though not significantly so until after aged 1 year. The overall mean weight for males was 41.4 kg, whereas that for females was 29.0 kg. Adult males averaged 60.5 kg, compared to adult females at 41.0 kg. The heaviest pig taken was a 5-year-old male weighing 148.1 kg. Mean weights for males increased consistently until 45 months, after which weights remained relatively stable. Females showed consistent weight increase until 33 months and fluctuated little thereafter. Seasonal weight changes were significant for males ( $p < 0.001$ ), though females showed no significant variation. Overall mean length for males was 121.7 cm, whereas that for females was 111.7 cm. The longest pig was a 4 year old male at 197.3 cm. Males gain in length at a slightly faster rate than females. Males had consistently longer, taller mandibles and taller condyles than females. Feral pigs in New Zealand have body growth rates comparable to wild boar of Europe and feral hogs from USA. All growth variables measured indicated high correlation. Feral pigs exhibited obvious sexual dimorphism with males heavier and longer than females in each age class. Growth is completed at the age of 3–4 years, somewhat later for males than for females.

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### Introduction

Feral pigs *Sus scrofa* L., 1758 are an important recreational hunting resource in New Zealand. Annual harvest for the northern South Island only (65,560 km<sup>2</sup>) is estimated at 20,000–25,000 (C. M. H. Clarke and R. M. Dzięciołowski, unpubl.), and the national harvest appears likely to exceed 100,000 animals. Despite the abundance of feral pigs in New Zealand, their biology is poorly documented. Knowledge of body weight and length, as well as jaw size, in relation to animal age, sex, and season of the year, are important for a wider understanding of the species biology. The aim of this paper is to describe patterns of physical growth in feral pigs, and in particular identify differences arising from age, sex, and season. Acquisition of these data were aimed at more informed management of the feral pig resource.

This study is part of a wider study of the biology and harvest capacity of feral pigs from throughout the northern half of the South Island. Previous papers have described the sex and age structures of the population (Dzięciołowski and Clarke 1989) and the effects of recreational hunting on the resource (Clarke 1989).

### Methods

Data on 2,674 autopsied pigs were collected between July 1986 and October 1987 and included date and location of kill, sex, field-dressed weight (gutted, heart, lungs, head and hocks attached), and body length (measured from tip of snout to base of tail). Pigs were aged using both tooth replacement and tooth wear for juveniles, and dental cementum for adults (Hayashi *et al.* 1977). Skeletal growth was determined from the length, height, and condyle height of the mandible (Fig. 1). Whole pig growth was subsequently determined from dressed body weight, body length, and weight/length ratios. Not all measurements were recorded for each animal.

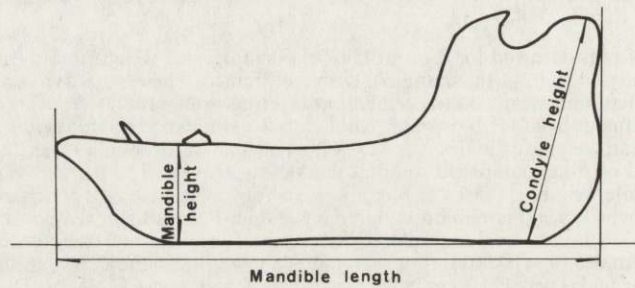


Fig. 1. Jaw measurements.

All data were analysed using the SAS computer package (SAS, 1985). Analyses and statistical methods used included analysis of variance, calculation of mean and 95% uncertainty limits (Andrews *et al.* 1980), multiple comparison (Duncan's Multiple Range Test and Least Significant Difference), and regression analysis. When the raw data deviated significantly from normality, parametric analyses used transformed

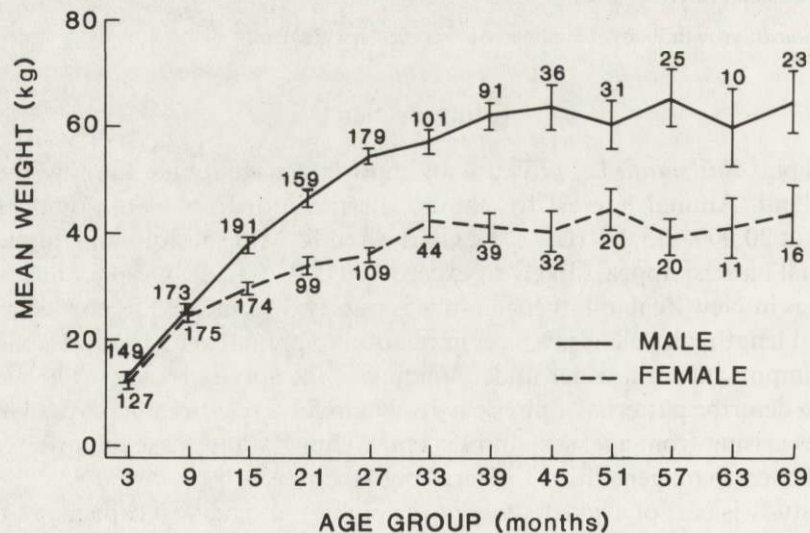


Fig. 2. Mean pig dressed weight by age group and sex with 95% uncertainty limits. Sample sizes are included. Mid-points of age groups are shown. Older age groups were omitted because of low sample sizes.

data and all graphs and tables of means were back-transformed to the original scale.

When growth variables were regressed against age, actual ages in months rather than age group were used (Dzięciołowski and Clarke 1989). Monthly and seasonal variation in weights were examined using animals older than 24 months.

## Results

### Body weight

Pig dressed weights varied significantly by sex ( $F_{1,2038} = 547.83$ ,  $p < 0.001$ ) and age group (as defined in Dzięciołowski and Clarke 1989) ( $F_{21,2038} = 148.56$ ,  $p < 0.001$ ). There was also a significant sex variation within the age structures ( $F_{17,2038} = 9.17$ ,  $p < 0.001$ ) (Fig. 2).

Males were consistently heavier than females from birth onwards, though not significantly so until after aged 1 year. The overall mean weight for males was 41.4 kg, whereas the overall mean weight for females was 29.0 kg, 25% lighter. Adult males averaged 60.5 kg, compared to adult females at 41.0 kg. The heaviest pig taken was a 5-year-old male weighing 148.1 kg (Fig. 3). Males also gain weight at a slightly faster rate than females, *i.e.*

$$\begin{aligned} \text{weight males} &= 5.0 \times \text{age}^{0.68} \quad R^2 = 0.6973; \\ \text{weight females} &= 6.30 \times \text{age}^{0.51} \quad R^2 = 0.5560. \end{aligned}$$

The fitted equations may be steeper than in reality because of insufficient numbers of pigs taken older than 6 years (72 months) compared to pigs taken younger than 6 years.

Males reach 50% of their adult weight at 12–15 months and about 75% of their adult weight by 21 months. Mean weights for males increased consistently until 45 months, after which weights remained relatively stable (Fig. 2). By comparison, females attained 50% of their adult body weight at 9 months and 75% of their adult weight by 15 months. Females showed consistent weight increase until 33 months and fluctuated little thereafter.

Monthly variations in weight differed significantly ( $F_{11,806} = 341.92$ ,  $p < 0.001$ ) with both males and females in April–May being significantly heavier than in August–September (Fig. 4). A decrease in mean weight by females in March, was reflected by a similar weight loss by males in February. On regrouping the months into seasons, seasonal weight changes were significant for males ( $F_{3,511} = 5.52$ ,  $p < 0.001$ ), though females showed no significant variation. Males reach peak weight in autumn, lose it during winter–spring, and then start gaining weight during summer. Females show a similar pattern to males, though with less seasonal fluctuation and a peak spread over autumn and winter. Regrouping of data into seasons smoothed a lot of the monthly variation (Fig. 5).

### Body length

Pig length varied significantly by sex ( $F_{1,1622} = 23.05$ ,  $p < 0.001$ ) and age group ( $F_{21,1622} = 90.86$ ,  $p < 0.001$ ) and also varied significantly by sex within age structures

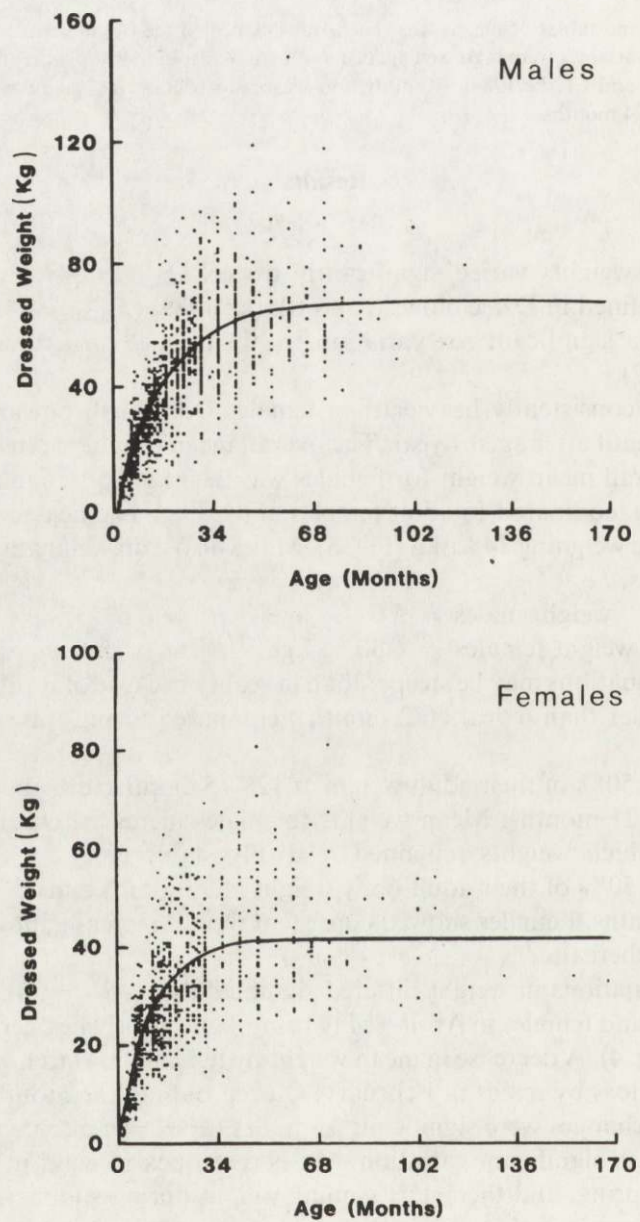


Fig. 3. Growth curve for pig dressed weight.

( $F_{17,1622} = 2.47$ ,  $p < 0.001$ ) (Fig. 6), with males being consistently longer than females. Overall mean length for males was 121.7 cm, whereas that for females was 111.7 cm, 8.2% shorter. The longest pig was a 4-year-old male at 197.3 cm. Regression analysis of female and male length and age data gave the following equations:

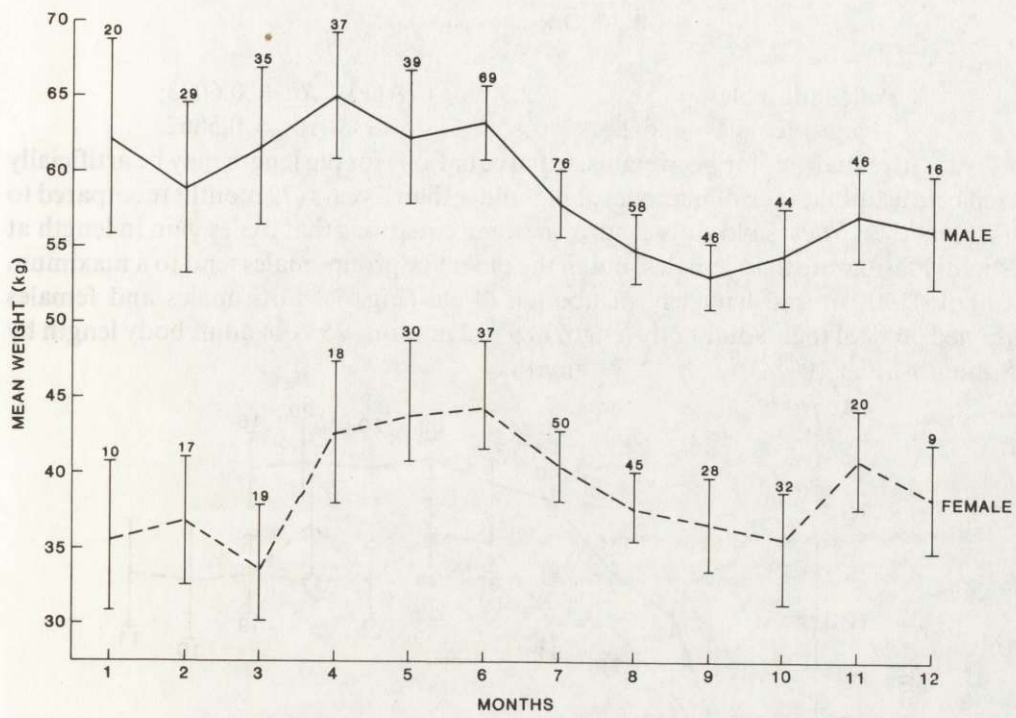


Fig. 4. Mean monthly dressed weight of pigs with 95% uncertainty limits. Sample sizes are included.

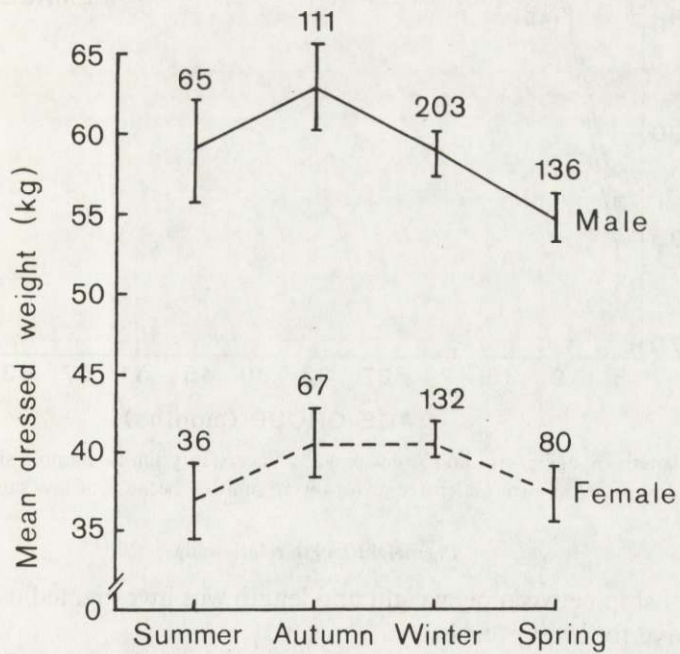


Fig. 5. Mean seasonal dressed weight of pigs with 95% uncertainty limits. Sample sizes are included.

$$\begin{aligned} \text{length males} &= 51.62 + 22.30 \log_e (\text{Age}) & R^2 &= 0.6083; \\ \text{length females} &= 6.22 \times \text{Age}^{0.20} & R^2 &= 0.5862. \end{aligned}$$

As with equations for pig weights, fitted equations for pig length may be artificially steep because of the lack of numbers of pigs older than 6 years (72 months) compared to those less than 6 years old. It is clear from these equations that males gain in length at a slightly faster rate than females, but in the older age groups males tend to a maximum of about 130 cm and females—of about 120 cm (Fig. 7). Both males and females attained 50% of their adult body length at 9–12 months, 75% of adult body length by 18 months, and 100% by about 39 months.

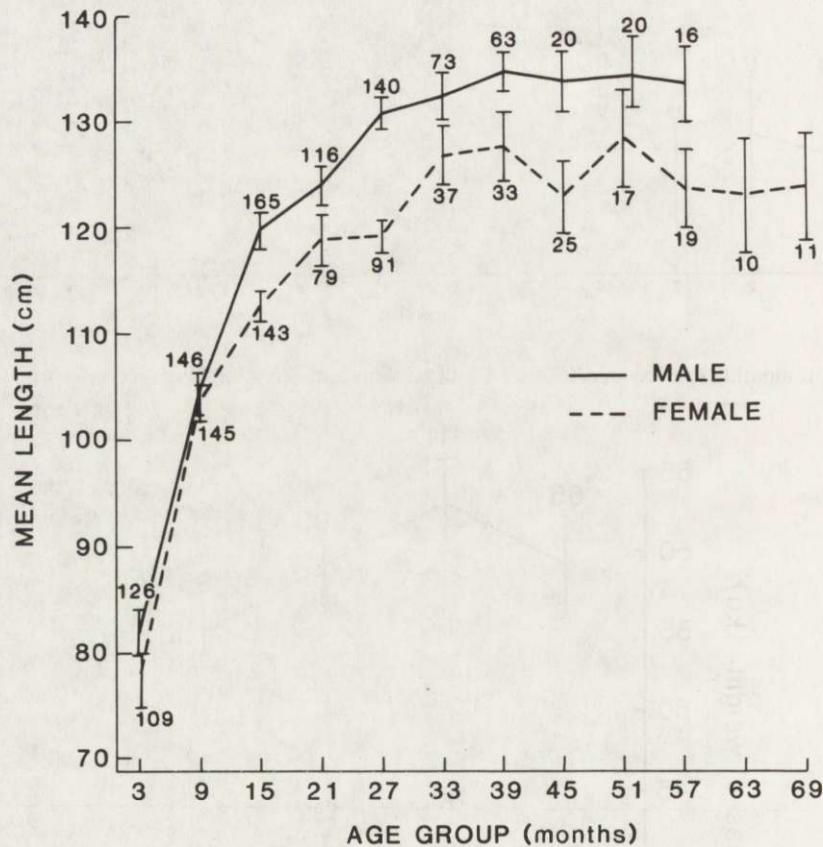


Fig. 6. Mean pig length by age group and sex with 95% uncertainty limits. Sample sizes are included. Mid-point of age groups are shown. Older age groups were omitted because of low sample sizes.

#### Pig weight/length relationship

The relationship between pig weight and length was investigated using regression analysis and gave following results:

$$\begin{aligned} \text{weight males} &= 1.989 \times \exp. (0.025 \times \text{length}) & R^2 &= 0.7586; \\ \text{weight females} &= 1.953 \times \exp. (0.024 \times \text{length}) & R^2 &= 0.7106. \end{aligned}$$

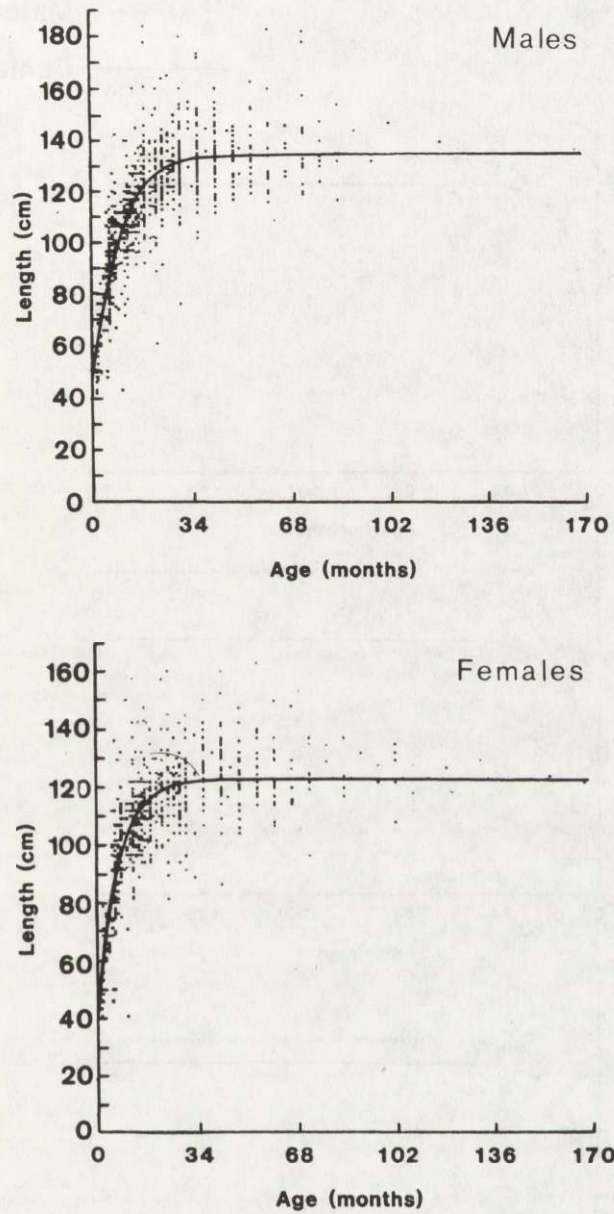


Fig. 7. Growth curve for pig length.

These equations show that weight/length relationships of males and females are similar. The weight/length data for males was more variable than that for females, especially for the larger animals.

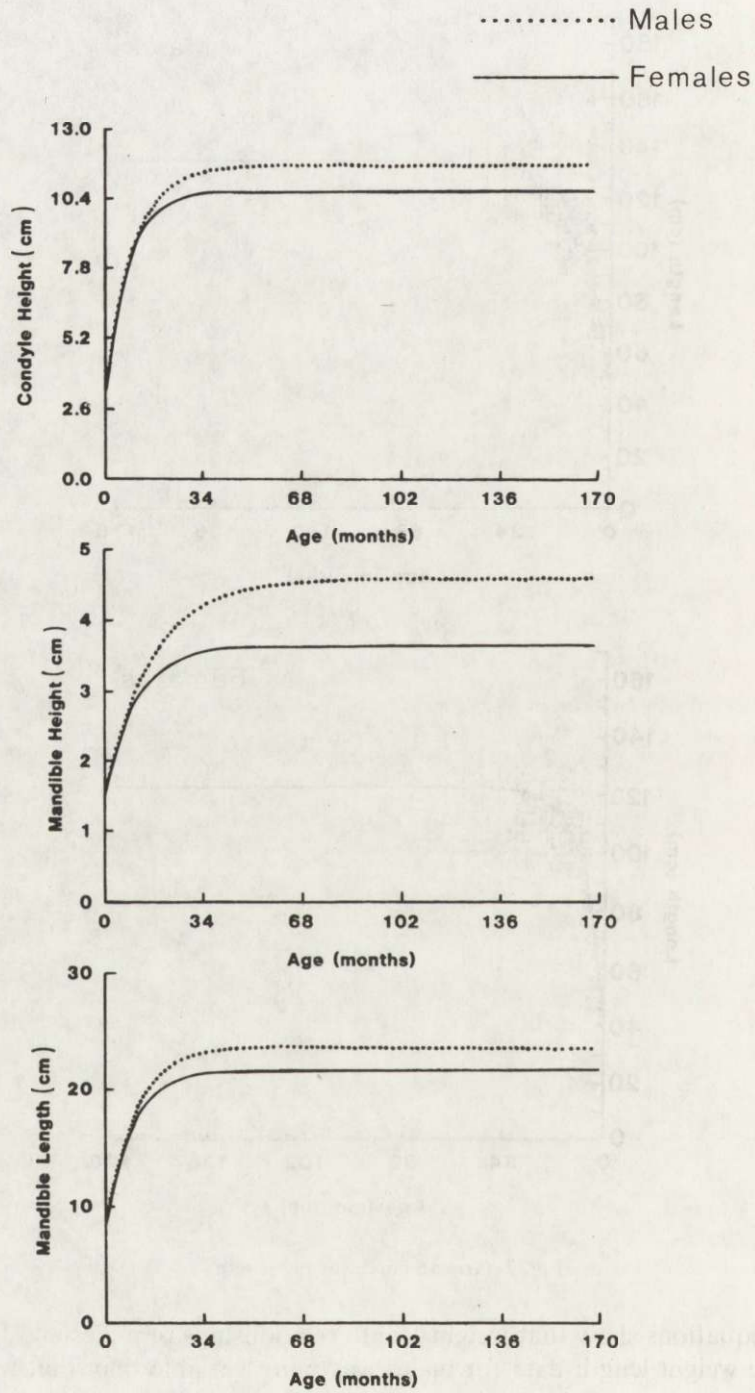


Fig. 8. Growth curves for pig mandibles.



## Jaw measurements

All mandible growth measurements (length, height, and condyle height) varied significantly by sex and age group, and also within age groupings ( $p < 0.001$ , Table 1). Males had consistently longer, taller mandibles and taller condyles than females (Fig. 8) and on average, were 8–13% larger than those of females.

Table 1. Variation in jaw size with age and sex (\*\*  $p < 0.001$ ).

Source	Mandible length		Mandible height		Condyle height	
	DF	F	DF	F	DF	F
Sex	1	65.8**	1	18.0**	1	44.8**
Age	20	339.4**	21	33.6**	20	261.1**
Sex/Age group	17	7.7**	17	1.9**	17	6.2**
Error	1852		2067		1834	
n	1890		2106		1872	

Table 2. Correlation coefficients between jaw measurements and other growth indices ( $p < 0.01$ ).

	Mandibular		Condyle
	length	height	height
Mandibular length	1.0	0.9329	0.9534
Mandibular height	0.9329	1.0	0.8952
Condyle height	0.9534	0.8952	1.0
Body weight	0.8349	0.8328	0.8041
Log (weight)	(0.9065)	(0.8489)	(0.8932)
Body length	0.8646	0.8084	0.8515
Age	0.6805	0.6795	0.6644
Log (age)	(0.8872)	(0.8323)	(0.8852)
<b>Males only</b>			
Mandibular length	1.0	0.9336	0.9542
Mandibular height	0.9336	1.0	0.9088
Condyle height	0.9542	0.9088	1.0
Body weight	0.8603	0.8489	0.8378
Log (weight)	(0.9196)	(0.8613)	(0.9078)
Body length	0.8612	0.8160	0.8456
Age	0.7359	0.7831	0.7240
Log (age)	(0.9080)	(0.8889)	(0.9037)
<b>Females only</b>			
Mandibular length	1.0	0.9354	0.9505
Mandibular height	0.9354	1.0	0.9982
Condyle height	0.9505	0.8892	1.0
Body weight	0.7711	0.7329	0.7484
Log (weight)	(0.8730)	(0.8132)	(0.8630)
Body length	0.8598	0.7961	0.8500
Age	0.6629	0.6481	0.6258
Log (age)	(0.9000)	(0.8475)	(0.8820)

All mandible measurements for males increased consistently until 39 months (Fig. 8). Males attained 50% of adult mandible length by 9 months and 75% by 15 months. Growth of mandible height and condyle height was slower and the 50 and 75% levels

attained at 15 and 21 months respectively.

Mandible measurements for females increased consistently until 33 months. Females attained 50% of adult mandible growth by 9 months and 75% of adult mandible length and condyle height by 21 months. The 75% level of adult mandible height was attained at 24–25 months. Overall, these results suggest that mandible growth for females occurs earlier than that of males, and ceases up to 18 months earlier. Mandible height for males was significantly larger than that for females throughout their lives.

#### Correlation of jaw measurements

All jaw measurements were highly correlated with each other both overall and within the sexes (Table 3). The other growth variables were also correlated with jaw measurements and the relationship with weight and age were improved by taking the logarithm of the variable (*i.e.*, a curvilinear relationship).

#### Discussion

Sample sizes used in this study varied from 1662 to 2674, depending upon the character measured. Harvesting of pigs was intensive and, together with the high productivity of the species, resulted in a sample biased towards juveniles. Although this contributed to some distortion of the fitted equations, it did not alter the overall patterns.

Analysis of weights and lengths reveal that the physical growth of feral pigs is completed when animals are 3–4 years old, and later in males than in females. Feral pigs reach 50% of their adult weight at 9–12 months and about 75% of their adult weight by 15–21 months (Fig. 2). Although the weight of males within an age group was variable, some males older than 5 years had greater weights than males in the 3–5 year group. This appears to result from a change in body form as older males develop heavy shields (cartilaginous padding across shoulders) and the neck and head region thickened with muscle and cartilaginous tissue. Larger size for males has obvious social advantages, as evidenced from the extent of woundings and scar tissue on adult boars. Despite the presence of large old males, the majority of pigs (males and females) appeared “past their prime” by the age of 6 years, probably because of tooth wear and loss and damage to tusks which would have affected their feeding (C. M. H. Clarke and R. M. Dzieciolowski, unpubl.). Except for old and diseased pigs, most were in good condition. Accordingly, maximum weights probably approximate the limits for feral pigs in this area.

The generally advanced state of growth of young females compared to young males appears associated with minimum body size requirements for sexual maturity (at 5 months in some animals, R. M. Dzieciolowski and C. M. H. Clarke, unpubl.). Because of early and frequent breeding of females, energy is diverted into reproduction rather than into further growth, and male growth increases relative to that of females

between 9 and 15 months. Skeletal growth in both sexes occurs at the expense of soft body tissue as elongation occurred over a similar 39 month period. All other growth variables were attenuated for males with slight but consistent body weight and mandible growth continuing on average 16 months longer than for females.

Average carcass weight of New Zealand feral pigs does not deviate much from that of wild boars from Europe and hybrids from USA (Table 3). Wild boars from Lithuania (Janulaitis 1988) are obviously heaviest among those compared. Similarly, average body lengths of pigs in New Zealand were again comparable with wild boar populations, at least those from East Germany (Table 4). Again, wild boars from Lithuania were longer than those from East Germany and feral pigs from New Zealand.

Table 3. Comparison of feral pig dressed weights (in kg) with those of wild boars from Europe and North America. Note in Methods the definition of field dressed weight as used in this study. In Europe field-dressed weight means that heart and lungs are removed along with gut viscera.

Country	Age								Source
	Piglets		Yearlings		Females > 2 yrs old		Males > 2 yrs old		
	$\bar{x}$	n	$\bar{x}$	n	$\bar{x}$	n	$\bar{x}$	n	
Hybrid wild boar from USA	18.4	172	41.3	142	50.2	155	59.4	112	Henry 1970
Feral pig from New Zealand	18.5	624	37.5	623	39.6	315	64.3	526	this study
Wild boar:									
East Germany	22.6	196	45.6	276	61.1	58	72.1	101	Briedermann 1970
Poland	23.7	370	37.9	1094	59.0	493	65.5	1101	Milkowski and Wójcik 1984
Lithuania	29.0	52	58.3	30	83.9	39	96.9	57	Janulaitis 1988

Table 4. Comparison of feral pig total lengths (in cm) with those of wild boars from Europe.

Country	Age								Source
	Piglets		Yearlings		Females > 2 yrs old		Males > 2 yrs old		
	$\bar{x}$	n	$\bar{x}$	n	$\bar{x}$	n	$\bar{x}$	n	
Feral pig from New Zealand	92	526	119	503	125	264	137	369	this study
Wild boar:									
East Germany	100	196	126	285	136	60	143	104	Briedermann 1970
Lithuania	29.0	52	58.3	30	83.9	39	96.9	57	Janulaitis 1988

Physical growth in New Zealand pigs also occurs over an equivalent period (3–4 years) to that found by Briedermann (1970) for wild boars in central Europe, and by Barrett (1978) for feral hogs in California. The Lithuanian wild boar however, completes its body growth at the age of about 5 years (females) and 6–7 years (males),

(Janulaitis 1988).

High correlation between weight and length found in our material was also noted by Brisbin *et al.* (1977) for feral hogs in south-eastern USA and by Janulaitis (1988) for wild boar in north-eastern Europe. Contrary to Brisbin *et al.* findings, however, both we and Janulaitis (1988) found an obvious sexual dimorphism in all growth variables measured.

### Conclusions

Feral pigs in New Zealand have body growth rates comparable to wild boar of Europe and feral hogs from USA. All growth variables measured indicated high correlation. Feral pigs exhibited obvious sexual dimorphism with males heavier and longer than females in each age class. Growth is completed at the age of 3–4 years, but somewhat later for males than for females.

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