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Breeding Biology and Haul-out Pattern of the New Zealand Fur Seal, *Arctocephalus forsteri*, at Cape Gantheaume, South Australia

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Abstract

New Zealand fur seals, *Arctocephalus forsteri*, breed at Cape Gantheaume (36°04'S, 137°28'E), Kangaroo Island, South Australia, on broken rock platforms. In 1988–89, pups were born between late November and mid-January, 90% of them over 34 days between 3 December and 6 January. The median date of birth was 21 December. A re-analysis of data for this species from three breeding seasons at the Open Bay Islands (South Island, New Zealand, 43°52'S, 168°53'E) indicates that: (i) the breeding season at Cape Gantheaume occurs 5–12 days later than at the Open Bay Islands, (ii) the period containing 90% of births was the same duration for both populations, and (iii) the median date of birth spanned seven days in three seasons at the Open Bay Islands. In addition, the timing and duration of the pupping season varied within the Cape Gantheaume colony, it being later in recently colonised areas. We suggest that this pattern is a consequence of changes in the age distribution of females through the colony. The sex ratio of pups born in the colony over four breeding seasons did not differ significantly from 1:1. Females were mated on average 7.4 days after birth and left for sea 2.3 days later. The mean date of observed matings was 29 December; copulations lasted about 13 min. The operational sex ratio (OSR) in the colony was 8.6 females per territorial male (the maximum ratio of territorial males to pups was 1:16), which was within the range reported for other southern fur seal species. In two consecutive breeding seasons, the estimated fecundity rate of adult females averaged 67%. Non-breeding animals (sub-adult males, juveniles and yearlings) occurred in areas not occupied by breeding animals. The number of juveniles ashore increased after the breeding season, but no pattern was found for sub-adults and yearlings. Yearlings were uncommon in the colony at all times; it is suggested that they are mostly pelagic and do not moult in their second year.

Introduction

The New Zealand fur seal, *Arctocephalus forsteri*, breeds on islands off coastal South Australia, Western Australia and Tasmania, and on rocky coasts and off-shore islands of New Zealand and its subantarctic islands (Mattlin 1987; Ling 1987; Brothers and Pemberton 1990). There have been several studies on aspects of the breeding biology of New Zealand populations of *A. forsteri* (Miller 1974; Crawley 1975; Mattlin 1981), and one in Australia (Stirling 1971a, 1971b), but no detailed information is available on the timing and duration of the breeding season for any Australian population. Here we present data on that topic, its variation throughout the breeding colony and other aspects of the breeding biology of *A. forsteri* at Cape Gantheaume, South Australia. Incidental information on oestrus, copulation, fecundity, degree of polygyny and changing composition of age and sex categories throughout the breeding season is also presented.

Methods

Field work was conducted at Cape Gantheaume (36°04'S, 137°28'E) (Fig. 1) between 29 November 1988 and 3 February 1992. Apart from continuous monitoring of the colony between 30 November

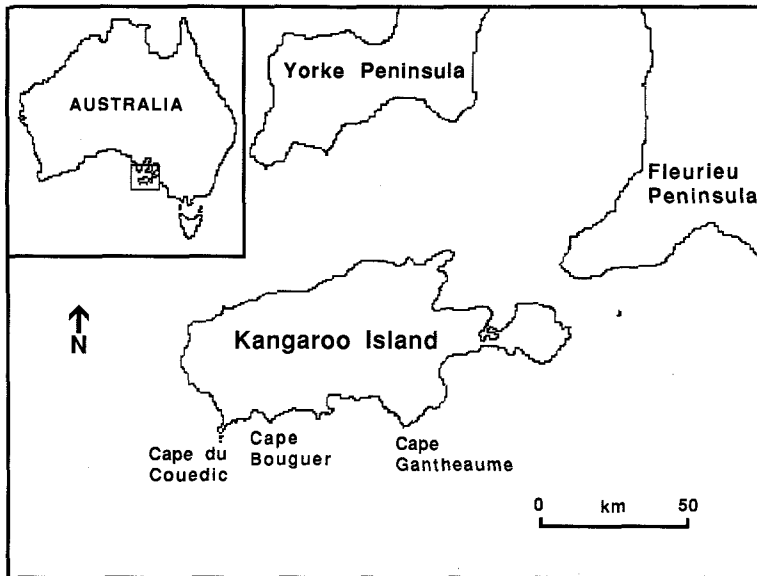


Fig. 1. Location of Cape Gantheaume ($36^{\circ}04'S, 137^{\circ}28'E$), Kangaroo I., South Australia.

1988 and 6 February 1989, other field trips were about one month in duration, occurring in January, April–May, July–August and October–November of 1990. Two more post-breeding season visits were made in January of 1991 and 1992. Data on the breeding biology of *A. forsteri* were derived from the 1988–89 breeding season.

In order to determine the duration of the pupping season, the median date of births and the number of fur seals using the colony, censuses were conducted every four days over the entire colony between 1 December 1988 and 6 February 1989. Between 9 December 1988 and 2 January 1989 additional censuses of pups were conducted every second day between the four-day censuses. Censuses commenced between 0830 and 0845 hours at the western end of the colony and took 2.5–3.5 h to complete. Binoculars were used to observe animals from the slopes or cliffs above the colony. Animals ashore were recorded in the following age and sex categories.

- (i) Adult males: mature males, possessing well-developed chests, manes and shoulders.
- (ii) Sub-adult males: males, as big or slightly larger than adult females, but distinguished from them by shoulder development, larger head and pointed snout.
- (iii) Adult females: mid-sized animals with smaller, sleeker heads than males, but lacking the large pointed snout and shoulder development.
- (iv) Juveniles: smaller than adult females and sub-adult males, but larger than yearlings.
- (v) Yearlings: small seals, distinguished from moulted pups by their larger, more pointed snouts, pale muzzle, white moustachial vibrissae and their rusty-coloured pelage.
- (vi) Pups: seals less than one year in age, with black natal pelage persisting as late as June in some animals, then moulting to adult-type pelage.

Two classes of adult male were recognised during the breeding season: 'territorial males', which hold territories with breeding females, and 'bachelor males', which hold territories without breeding females.

A modified probit analysis (Caughley 1980) was used to determine the duration and standard deviation of the pupping season and the median date of birth. This indirect method was used because neither the beginning nor the end of the season of births was sampled. Information on the timing of oestrus was determined by observation of paint-marked females. Females were marked within a day of giving birth using paint pellets fired from a sling-shot. Data on fecundity were obtained by observation of tagged adult females in the colony between 1989 and 1991.

Pups were marked in mid-late January in each of five summers as part of a study to determine trends in their abundance. At the same time, the sex of each pup was determined by inspection of the vent.

The extent of polygyny in otariid seals has been measured in various ways. Boness (1991) used three measures to determine the extent of polygyny in otariid seals: (i) the operational sex ratio (OSR), (ii) an index of sexual selection (I_s), and (iii) the maximum number of females mated by a single male. In this study, the level of polygyny was estimated by the OSR, which is defined as 'the average ratio of fertilisable females to sexually active males at any given time' (Emlin and Oring 1977). OSR provides an empirical measure of the degree to which mates can be monopolised (Emlin and Oring 1977), and can be estimated by determining the number of males resident among females or pups, whichever is greater (Boness 1991). In the study presented here, OSR was derived by dividing the pup production of the main breeding colony by the maximum number of territorial males observed there.

Results

Habitat

The fur seal colony extended from Cape Gantheaume north-eastward for about 1.5 km (Fig. 2). Here *A. forsteri* haul-out and breed on irregular rock (Kanmantoo schist) platforms. For convenience the colony has been divided into sectors, from A (at the western end) to I (at the eastern end) (Fig. 2). The main breeding colony extended 350 m (Sector A to the western part of Sector E), most of which was north-east of the Cape. It also included the headland and small area to the west. Steep slopes and cliffs composed of sand and limestone rise behind the rock platform to a height of about 50 m. Pups were also born at other sites up to 900 m east of the main colony, but in small discrete groups separated by areas of rock platform not used by breeding animals (from part of Sector E through to I; Fig. 2). During the course of the study these groups of pups were found further away from the main breeding colony in areas used primarily by non-breeding seals.

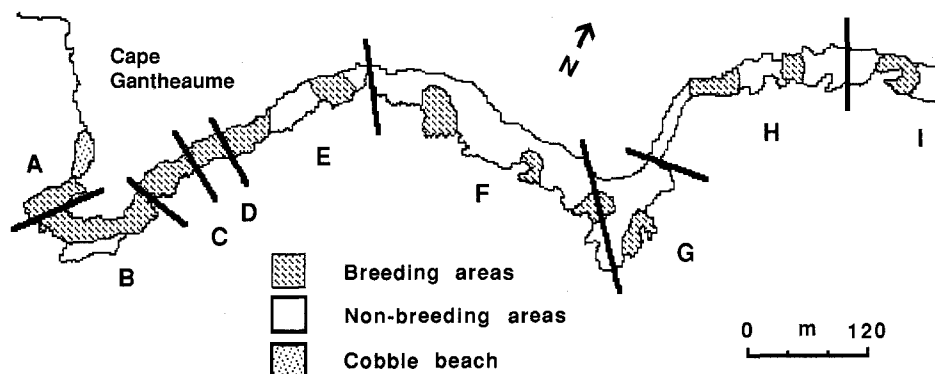


Fig. 2. Rock platform areas at Cape Gantheaume used by *Arctocephalus forsteri*. Hatched areas indicate pupping localities. Most breeding occurred in the large hatched area extending north-eastward from Cape Gantheaume. Census sector boundaries are also marked.

Breeding areas were centred around regions where the rock platform was most irregular, and were often associated with pools. Open, flat areas where schist outcropping was minimal, and areas strewn with small rounded boulders, were least favoured. Vegetated areas and small caves and grottos formed in the limestone behind the colony were also used, particularly by pups and juveniles, during heavy seas. The habitat at Cape Gantheaume is similar to that used by *A. forsteri* at other locations on Kangaroo Island (Cape du Couedic and Cape Bouguer).

Pupping Season

Two pups had already been born in the Cape Gantheaume colony by 29 November 1988. There was a sigmoidal increase in pup numbers until early January, the last birth being recorded on 18 January 1989 (Fig. 3). Seven births were observed, five (71%) of which were breech presentations. Of 24 births observed by McNab and Crawley (1975) in *A. forsteri* on the Open Bay Islands, 11 (46%) were breech presentations, but on South Neptune Island, South Australia, only one of five births observed by Stirling (1971*b*) was in a breech position.

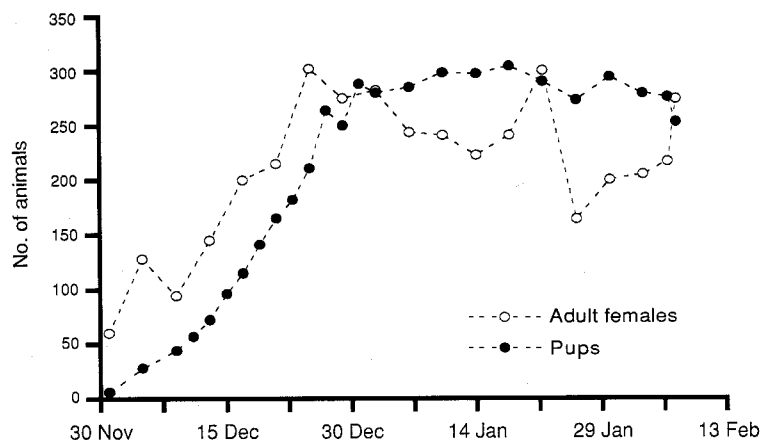


Fig. 3. Numbers of adult females and pups of *Arctocephalus forsteri* at Cape Gantheaume from November 1988 to February 1989.

At Cape Gantheaume, 90% (412 of a total of 458 born; Shaughnessy, Goldsworthy and Libke, unpublished data) of pups were born over a 34-day period (4.9 weeks) from 3 December to 6 January. The median date of birth was 21 December. The standard deviation of the pupping season was 10 days (Table 1). Both the timing and duration of the pupping season were found to vary within the Cape Gantheaume colony. A cline of increasing median birth date from Sectors A–B through to Sectors E–G is apparent in Fig. 4, and from analysed data presented in Table 2.

Table 1. Comparison of pupping season data from Cape Gantheaume, Kangaroo I., South Australia and the Open Bay Is, South I., New Zealand

Site, season	Median pupping date	s.d. (days)	90% of births (days)	No. of censuses
Cape Gantheaume (36°04'S)				
1988–89	21 Dec.	10.3	34	19
Open Bay Is (43°52'S)				
1970–71 ^A	9 Dec.	10.2	33	9
1974–75 ^B	16 Dec.	10.6	35	10
1975–76 ^B	9 Dec.	5.9	20	7

^AData from Miller (1971).

^BData from Mattlin (1978*b*).

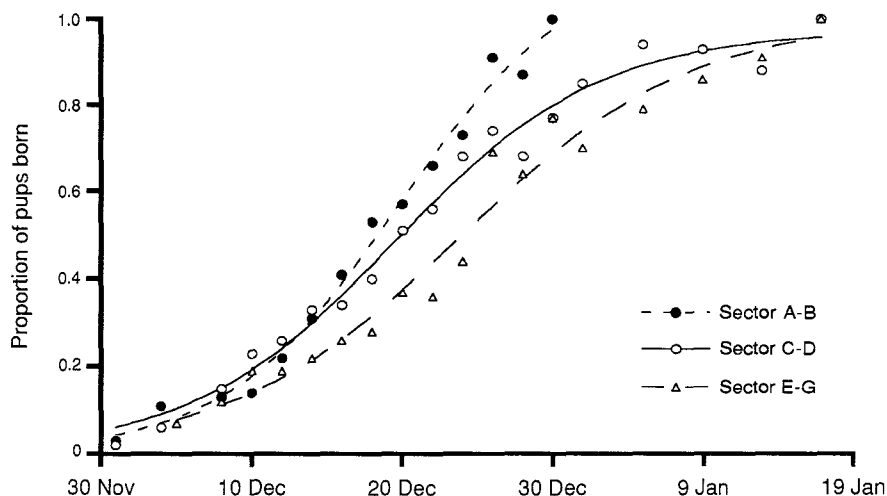


Fig. 4. Variation in the timing and extent of the pupping season in *Arctocephalus forsteri* throughout three sectors of the Cape Gantheaume colony during the 1988–89 breeding season.

Table 2. Variation in the timing and duration of the pupping season in three sectors of the colony of *Arctocephalus forsteri* at Cape Gantheaume in the 1988–89 breeding season, in relation to rate of increase (r) in pup production from 1988–89 to 1991–92

Sectors	Median pupping date	s.d. (days)	90% of births (days)	r^A
A–B	20 Dec.	8.9	28	0.10
C–D	23 Dec.	12.5	40	0.12
E–G	26 Dec.	13.8	41	0.28 ^B

^A Exponential rate of increase (r) from Shaughnessy, Goldsworthy and Libke, unpublished data. ^B Refers to Sectors E–I.

Sex Ratio of Pups

The proportion of male pups aged about four weeks in the four seasons ranged from 0.491 to 0.537 (Table 3). None of the proportions differed significantly from 0.5. The proportions of male and female pups also did not differ when data were combined for the four years.

The sex ratio of marked pups was also determined in each sector of the colony. In three of the four summers the proportion of male pups was lower in the north-eastern (or newer) part of the colony than in the western (older) part. This difference was not significant in any season (Table 4).

Oestrus and Copulation

In mid–late November 1988 and 1989, adult females were scarce in the breeding colony, but in early December they began to haul-out and give birth. Seven paint-marked females were observed mating 7.4 days (s.d. = 1.0) after birth. Miller (1974) found a similar time interval for *A. forsteri* at the Open Bay Islands (mean = 7.9 days, s.d. = 1.9, $n = 11$). At Cape Gantheaume adult females left the colony 2.3 days after mating (s.d. = 2.5, $n = 8$). The

Table 3. Proportion of male pups of *Arctocephalus forsteri* born in four seasons at Cape Gantheaume χ^2 (with 1 d.f.) is testing for deviations from a 1:1 ratio

Pupping season	No. of pups		Proportion male	χ^2
	Male	Total		
1988-89	217	442	0.491	0.14
1989-90	174	351	0.496	0.03
1990-91	137	255	0.537	1.42
1991-92	296	560	0.529	1.83
Total	824	1608	0.512	0.99

Table 4. Sex ratio of pups of *Arctocephalus forsteri* born in the western and north-eastern part of the Cape Gantheaume colony over four years χ^2 (with 1 d.f.) is testing for deviations from a 1:1 ratio

Pupping season	Part of colony	No. of pups		Proportion male	χ^2
		Male	Total		
1988-89	Western	192	388	0.495	0.22
	North-eastern	21	47	0.447	
1989-90	Western	151	297	0.508	0.94
	North-eastern	23	54	0.426	
1990-91	Western	97	166	0.584	3.72
	North-eastern	40	89	0.449	
1991-92	Western	232	448	0.518	0.83
	North-eastern	64	112	0.571	

number of adult females ashore peaked around 25 December and then declined as they left for their first foraging trips to sea after their post-partum oestrus (Fig. 3).

Copulations were observed at Cape Gantheaume between 12 December and 9 January, with a mean date of 29 December (s.d.= 8.3, $n = 9$), eight days after the median date of birth. This is later than that recorded for *A. forsteri* at the Open Bay Islands, where matings in the 1970-71 season were observed between 13 November and 18 January, with a mean date of 16 December ($n = 54$) (calculated from Miller 1975). The earlier mean mating date at the Open Bay Islands can be attributed to the earlier pupping season there. In both populations the mean date of matings was 7-8 days after the median pupping date.

Four matings observed in their entirety at Cape Gantheaume had a mean duration of 13 min (s.d.= 3.5). Three of these were between a territorial male and different females within the male's territory. The other was by a sub-adult male, who sneaked a copulation within a territory while the attending male was asleep. In a much larger sample, Stirling (1971a) recorded 30 matings from start to finish; the mean duration was 6.6 min (s.d.= 2.19), which was shorter than that recorded in this study.

Fecundity Rate

Data on fecundity rate refer to the number of live births (of both sexes) of 30 females over three breeding seasons and two intervening lactation periods (Table 5). Females included in

Table 5. Fecundity rate in adult female *Arctocephalus forsteri* in two breeding seasons at Cape Gantheaume

Female status	1989–1990 (n = 12)	1990–1991 (n = 18)
Lactating–lactating	9 (75%)	11 (61%)
Lactating–not lactating	3 (25%)	5 (28%)
Not lactating–not lactating	–	2 (11%)

the analysis were tagged, were known to have pupped and were seen to return to the colony in each year. Of 12 females observed nursing pups during 1989, nine pupped in the following breeding season (1989–90). In the 1990–91 breeding season, of 18 females that nursed young in 1990, 11 had pups. Combined data gave an average fecundity rate of 67%. The calculated rate may be positively biased because animals were sampled in breeding colonies.

Haul-out Patterns of Adult Males and Younger Animals

Territorial males were observed defending territories as early as mid-October, some 1.5 months before the pupping season began. Vigorous defence of territories was not apparent until late November. The number of territorial males increased as more females came ashore to pup, while the number of bachelor males decreased concomitantly (Fig. 5). The number of territorial males ashore reached a maximum on 2 January, eight days after the peak in numbers of adult females ashore (Fig. 3). The number of territorial males declined as the number of females ashore began to decline. The OSR, determined by dividing the pup production of the main breeding colony by the maximum number of territorial males observed there, gave a ratio of 1:8.6. This was a minimum estimate because some males held territories without pups.

Throughout the non-breeding period the spatial arrangement of adult males in the breeding colony was similar to that observed during the breeding season, although territorial behaviour was much reduced. This pattern was also observed by Stirling (1971a).

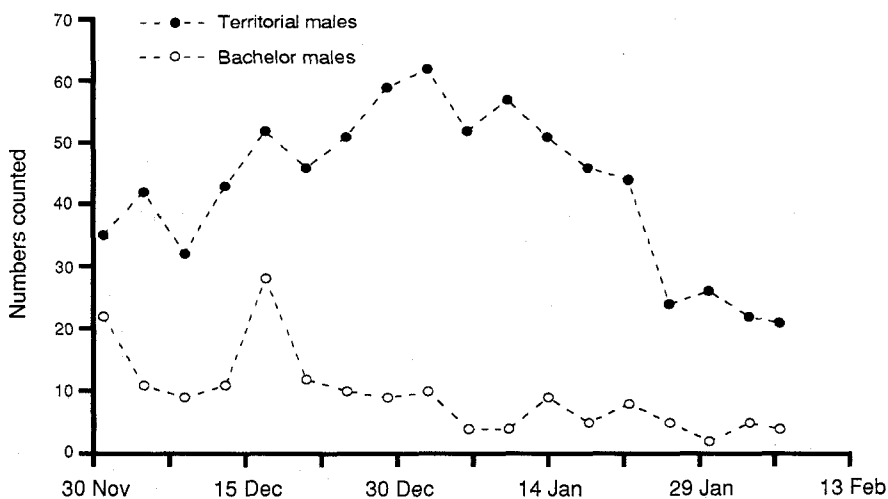


Fig. 5. Numbers of territorial and bachelor males of *Arctocephalus forsteri* at Cape Gantheaume from November 1988 to February 1989.

Non-breeding *A. forsteri* (sub-adults, juveniles and yearlings) were generally restricted to areas not used by breeding seals in part of Sector B, and to areas east of Sector E (Fig. 2). There was a major concentration of non-breeding seals at the unnamed cape where Sectors F and G meet. There was little pattern to the haul-out behaviour of non-breeding seals during the breeding season, with the exception of juveniles, whose numbers ashore increased at the end of the breeding season (Fig. 6).

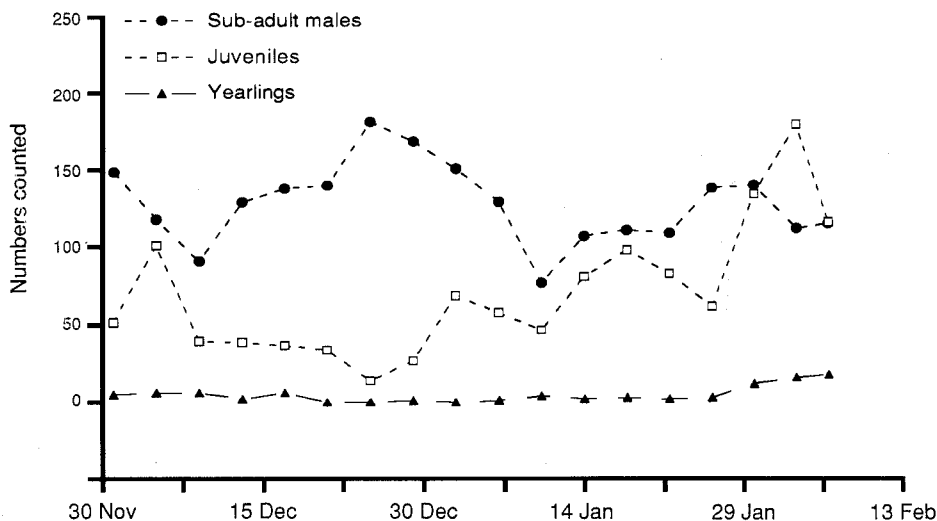


Fig. 6. Changes in the numbers of sub-adult male, juvenile and yearling *Arctocephalus forsteri* counted at Cape Gantheaume during the 1988–89 breeding season.

Discussion

Pupping Season

Stirling (1971a) recorded births of *A. forsteri* at South Neptune Island, South Australia, between 29 November and 22 January, with most births between 20 and 30 December, which is similar to the result for Cape Gantheaume. For the Open Bay Islands (South Island, New Zealand), pupping season data spanning three seasons are summarised in Table 1. Three comparisons can be made with these data and those from Cape Gantheaume.

First, the median pupping date at Cape Gantheaume is some 5–12 days later than at the Open Bay Islands (Table 1). This difference may represent real population differences in the timing of pupping throughout the latitudinal range of the species. Alternatively, as data are only available for one season at Cape Gantheaume, inter-population differences may be small compared with the variability between years at colonies (see below). Median dates of birth recorded across the substantial longitudinal range of populations of the Antarctic fur seal, *Arctocephalus gazella*, vary by only six days (Kerley 1983; Shaughnessy *et al.* 1988; Duck 1990; Shaughnessy and Goldsworthy 1990). A small range in the median date of birth is expected in a high-latitude species where strong seasonality may favour synchrony of pupping seasons. Other species such as harbour seals, *Phoca vitulina*, of the eastern North Pacific (Temte *et al.* 1991), South American fur seals, *Arctocephalus australis* (Majluf 1987; Vaz-Ferreira and Ponce de Leon 1987), and northern fur seals, *Callorhinus ursinus* (York 1987), show clinal variation in the timing of the breeding season in relation to latitude. For these species, breeding is earlier for populations at lower latitudes than at higher latitudes. In

populations of *A. forsteri* breeding at the Open Bay Islands and at Cape Gantheaume, the trend is reversed.

Second, three of the four data sets for Cape Gantheaume and the Open Bay Islands show no difference in the variation or spread of the pupping season, and the period during which 90% of pups were born (birth synchrony) (Table 1). The exception is the 1975–76 breeding season at Open Bay Islands; its apparently shorter season and smaller variance may result from fewer censuses. One comparative analysis suggested a strong relationship between birth synchrony (as measured by the period over which 90% of pups were born) and latitude among otariids (Boness 1991, fig. 1.2). As expressed, the analysis shows a negative relationship, although it should be appreciated that the period over which 90% of pups are born is an inverse measure of birth synchrony. Thus fig. 1.2 of Boness (1991) should be interpreted to indicate that pupping is more synchronous in higher latitudes. Boness attributed this to the seasonal availability of food resources.

Among the majority of otariids that breed in temperate and subpolar waters (25–60° latitude), birth synchrony varies little (see Boness 1991, fig. 1.2). The intraspecific comparison presented in this study between two populations of *A. forsteri* separated by about 8° of latitude, accords with this observation. Because otariids come into oestrus about a week after birth, Boness (1991) suggested that a degree of birth synchrony is required in order to enhance polygyny in otariids.

Third, the median pupping date at the Open Bay Islands varies between seasons, from 9 to 16 December (seven days) (Table 1). Median birth dates have been found to vary between years at several breeding sites. In *A. gazella* at Bird Island, median birth dates have been shown to vary by fewer than four days over five seasons (Duck 1990). Similar results have been reported for *C. ursinus* (Trites 1992). In a subtropical population of *A. australis*, Majluf (1987) found that median birth date shifted by eight days in two consecutive seasons. These data suggest a negative relationship between annual variability in the timing of the pupping season and latitude. Such relationships may reflect selection for greater birth synchrony in higher latitudes where there is greater seasonality in prey availability.

Variation in Timing of Pupping Throughout the Colony

The cline of increasing median birth date from Sectors A–B through to Sectors E–G may result from variation in the age distribution of adult females throughout the colony. Lunn and Boyd (1993) found that parturition date was negatively correlated with female age in *A. gazella*. Another study on *A. gazella* found the same relationship between female body length (a measure of relative age) and parturition date (Boyd and McCann 1989). In *C. ursinus*, older females were also found to pup earlier in the breeding season (Bigg 1986). The pup production of the Cape Gantheaume colony has increased at 16.2% per annum between 1988–89 and 1992–93 (Shaughnessy, Goldsworthy and Libke, unpublished data). This increase was mostly at the north-eastern section of the colony (Sectors E–G) (Table 2). Later birth dates in Sectors E–G indicate that many females are breeding there for the first time and will therefore be younger than those in Sectors A–B. A similar pattern of predominantly younger and primiparous females breeding in newly established colonies has also been reported in recovering populations of northern elephant seals, *Mirounga angustirostris* (Reiter *et al.* 1981).

Fecundity Rate

The fecundity rate of 67% reported for *A. forsteri* in this study is less than that reported for other otariids [subantarctic fur seals, *A. tropicalis*, 79% (for females older than 4 years) (Bester 1987); South African fur seals, *A. pusillus pusillus*, 77.5% (David 1987); Australian sea lions, *Neophoca cinerea*, 77% (Higgins 1990); Australian fur seals, *A. p. doriferus*, 73% (Warneke and Shaughnessy 1985)]. It is possible that fecundity rates were underestimated in this study as a result of pup mortality. In a population of *A. forsteri* breeding at the Open Bay

Islands in New Zealand, Mattlin (1978a) found that pup mortality was about 20% between birth and 50 days, and 40% between birth and 300 days. As searches for tagged females with pups were conducted in the breeding colony at Cape Gantheaume four months and one month after pupping season, in April 1991 and January 1992, respectively, some pups would have died during these intervals, creating biases in fecundity estimates.

Polygyny

The OSR of 1:8.6 recorded for *A. forsteri* at Cape Gantheaume is similar to that recorded for the same species on the Snares Islands, New Zealand (1:5) (Crawley 1972), and the related ratio of adult males to adult females (1:7.9) found by Miller (1975) at the Open Bay Islands. Stirling (1971a) recorded similar findings for *A. forsteri* at South Neptune Island where, in two separate colonies, he estimated the ratio of adult males to pups to be 1:6 and 1:8.

The OSR can also be estimated from the number of females giving birth in territories. In two territories at Cape Gantheaume where all pups were marked, the ratio of territorial males to pups was 1:12 and 1:16. The various estimates of OSR for *A. forsteri* were similar to those reported for most other species of fur seal (see Boness 1991, table 4). Exceptions are *C. ursinus* and *A. p. pusillus*, which have been reported to have OSRs 4–5 times those recorded for other species (Boness 1991).

Haul-out Patterns of Yearlings

Yearlings were absent during many of the censuses conducted during December and January, and were uncommon in the colony at other times. Some of the yearlings observed in August and November had small patches of guard hairs missing from their coat, where they had been clipped when weighed as moulted pups (April–November) in the previous year. These observations suggest that yearlings are mostly at sea and do not moult in their second year. As moult demands higher peripheral temperatures (Feltz and Fay 1966; Miller 1991), it is unlikely that yearlings could moult at sea. Unlike the pelage of other age-classes, that of yearlings is characterised by its rusty-coloured appearance, making them easily identifiable. In addition, they have grey–brown fur around their face and head, which, unlike the rest of their body, appears to have undergone moult. A moulted face and unmoulted body is consistent with a mostly pelagic existence in their second year, where the head and face would be the only parts of the body exposed to warmer temperatures.

Conclusion

The data presented here provide previously unreported information on the pupping season and haul-out patterns of a rapidly expanding colony of New Zealand fur seals. These will form a base for comparative studies of the same colony as it expands, and for other colonies throughout the range of the species.

Acknowledgments

We are indebted to the many volunteers who have assisted in the field, and to staff of the National Parks and Wildlife Service on Kangaroo Island, particularly T. Dennis and A. Maguire, for their support. Special thanks to E. H. Miller and R. H. Mattlin for providing pupping season data from the Open Bay Islands, New Zealand. A. K. Lee, J. M. Cullen and two anonymous reviewers made constructive comments on the manuscript. The following provided financial support for this project: the Wildlife Conservation Fund South Australia, CSIRO/Monash Collaborative Research Fund, CSIRO Institute for Natural Resources and the Environment Post-graduate Project Award, Australian Nature Conservation Agency, the M. A. Ingram Trust, the Victorian Institute for Marine Sciences, and the Museum of Victoria.

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