REPORT:

A FIELD STUDY OF THE LANCELIN ISLAND SKINK *CTENOTUS LANCELINI*

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FOR
The Department of Conservation and Land Management
Western Australia

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1. INTRODUCTION

In 1992 Browne-Cooper and Maryan published their concerns over what they believed to be a decline in the abundance of the Lancelin Island Skink (*Ctenotus lancelini*) on Lancelin Island. This prompted the Western Australian Department of Conservation and Land Management (CALM) to undertake limited trapping on Lancelin Island during November 1992 and March 1993 and only one *C.lancelini* was trapped (Rolfe 1993). *C.lancelini* was known only from rocky parts of Lancelin Island (Wilson and Knowles 1988), and it seemed that if the known distribution and Browne-Cooper and Maryan's (1992) observations of apparent decline were correct, the species may have been in immediate danger of extinction.

CALM subsequently sought and gained financial support for detailed studies of *C.lancelini* under the Federal Government's Endangered Species Programme. The major component of the studies was a field study of *C.lancelini* on Lancelin Island, which was conducted between December 1993 and December 1995.

This document describes the trapping programme used to collect data and summarises biological and population information about *C.lancelini* on Lancelin Island. Results of trapping the Lancelin foreshore reserves for *C.lancelini* are also presented. A discussion of proposed mangement strategies is included, along with the author's management recommendations.

At the commencement of this study very little was known about *C.lancelini* . The only preserved material consisted of 11 individuals held at the Western Australian Museum (5 from Ford's original collection, and 6 specimens collected by Hanlon and Petersen in April 1975). No specimens were known to exist in other collections. Most field knowledge of the taxa was anecdotal, and was held by a number of local herpetologists who had visited the Island in order to sight or photograph *C.lancelini* .

Ctenotus lancelini was first collected by Ford (1963) when he recognised it under the name of *Ctenotus labillardieri*. He subsequently (Ford 1969) named the Lancelin Island taxon *C. labillardieri lancelini*. Ford's recognition of the taxon was based primarily on the taxon's distinctive colour patterns, which served to distinguish it from all of the other populations he examined (which Ford referred to *C.labillardieri labillardieri*). Ford's numeric data (Ford 1969) showed that individuals of the Lancelin Island taxon were larger and had shorter hindlimbs (34% of SVL rather than 37-44%) than individuals of *C.l.labillardieri* .

Ford's numeric data (Ford 1969) also contained evidence of clinal variation in body-size and MBSR (the number of mid-body scale rows) in *C.l.labillardieri* populations: southern populations tended to have larger individuals with higher MBSR, and northern populations had smaller individuals with fewer MBSR. The Lancelin Island taxon included the largest individuals, but they also had the lowest number of MBSR. The three independant taxonomic characters (low MBSR count, short hindlimbs and distinctive colouration) taken with the evidence of an anomolous pattern of covariation in MBSR and body-size provide ample evidence that *C.lancelini* warrants the specific status recommended by Storr (1972).

Pianka (1969) studied resource partitioning between 14 sympatric *Ctenotus* in the Western Australian arid zone. He found that the species which tended to forage in more closed spaces (amongst or below vegetation) had proportionately shorter hindlimbs than did those which foraged in more open habitat (between clumps of vegetation), and concluded that "hindleg proportions can be used as a morphological indicator of the (species) 'place niche' ". Hindlimb length for Pianka's species ranged from 40-58 % of SVL, all of which were much longer than for *C.lancelini* .

Until CALM trapped one *C.lancelini* in November 1992, all members of species which had been handled were found in the course of turning rocks. This observation, taken with Ford's morphological data, and the general trend identified by Pianka for *Ctenotus* hindlimb lengths to reflect the structural nature of the favored foraging niche all suggested that *C.lancelini* was one of the more specialised *Ctenotus* in terms of adaptations for foraging 'under things'. This speculation was amongst the most reliable information about *C.lancelini* available at the commencement of the study, and it prompted the covered pit design used on Lancelin Island.

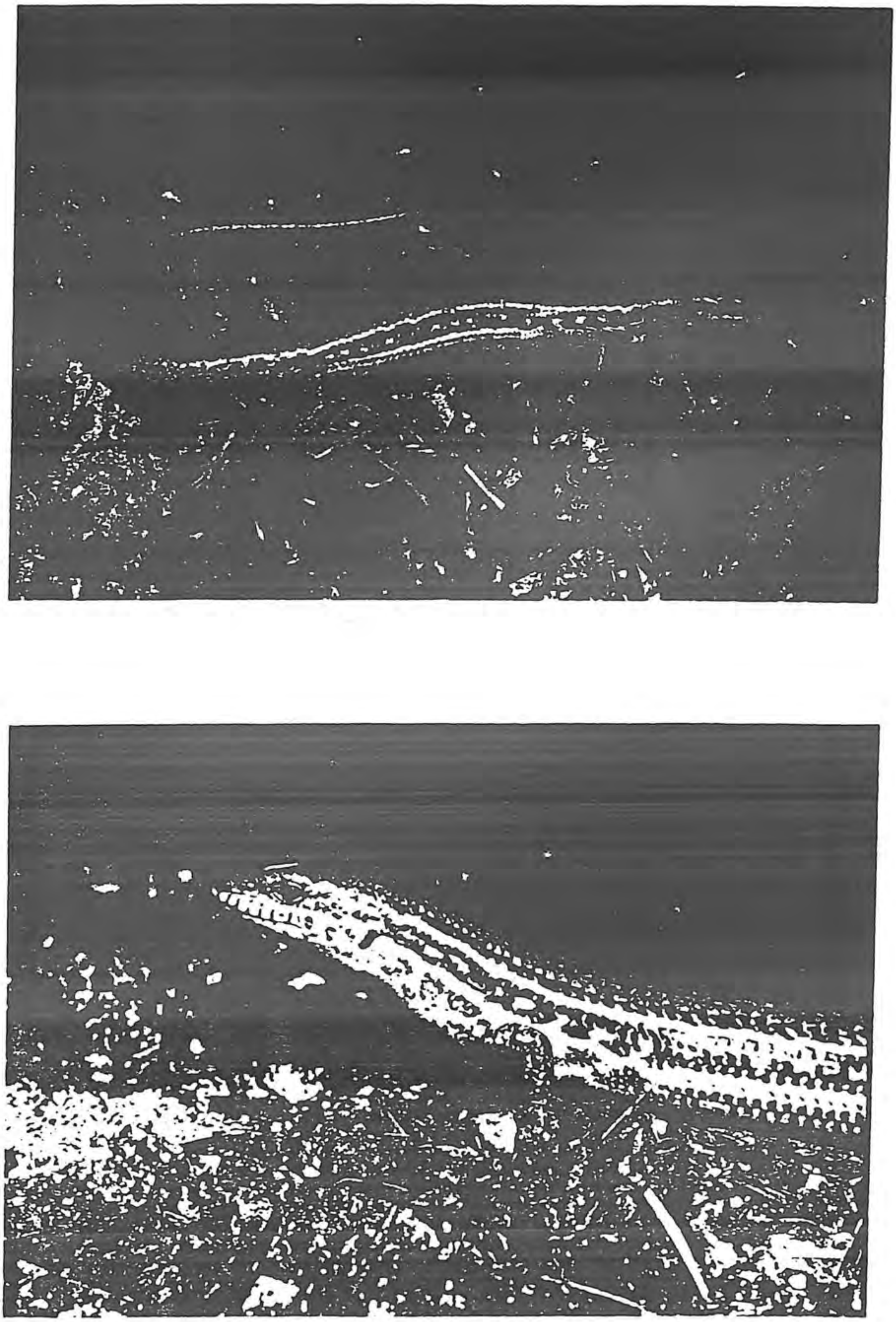


Figure 1. An adult female *C.lancelini*
(photographs by Magnus Petersen)

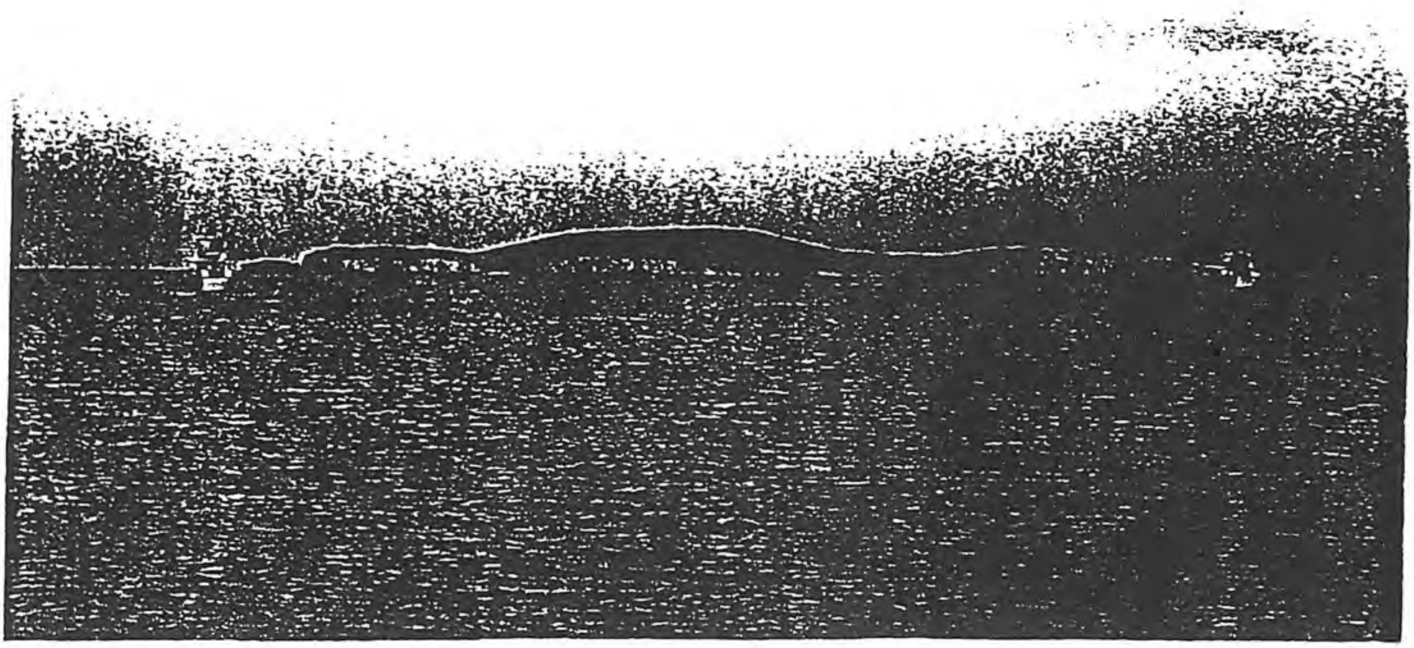


Figure 2. Lancelin Island, viewed from the east-south-east.

2. BACKGROUND

2.1. Study Outline

The initial and primary aim of the Lancelin Island study was to determine if the island population was in decline, and if so, to determine what environmental factors were causal in the decline. The secondary aim was to collect biological and ecological information about the Island population to facilitate informed decisions about the species and habitat management. A capture-mark-release trapping programme provided the best opportunity to satisfy both major aims, and was established during December 1993.

Initial captures of *C.lancelini* during 1994 indicated the species was widespread on the Island, and that recent hatchlings were not rare, which implied that the species was not at a critical point of decline. The study then concentrated on collecting population information.

In October 1994, a single specimen of *C.lancelini* was collected by hand from the Lancelin foreshore reserve adjacent to Lancelin Island (Maryan and Browne-Cooper 1995), but trapping in the area during November and December 1994 yielded no further captures (D. Pearson, pers. comm.). Trapping was also conducted in this area in November-December 1995 to obtain an estimate of the relative abundance which was directly comparable with contemporaneous Lancelin Island capture rates.

2.2 The Lancelin Island Study Area

Lancelin Island (Figures 2 & 3) lies at 31° 00' 30" S, 115° 18' 55" E. It has a total area of 7 ha, of which about 6.5 ha is vegetated and is dominated by a large central sand dune rising to 17 m with it's long axis running approximately NW-SE. On the eastern side of the Island, a narrow vegetated swale of white beach sand separates the central dune from the beach. This component was not present in 1976 (Nick Dunlop, pers. comm. with photographs taken in 1976). Shallow soil overlies limestone on the northern, southern and south-western extremities of the Island. Rocky cliffs or steep slopes with little vegetation extend from these areas to the water-line.

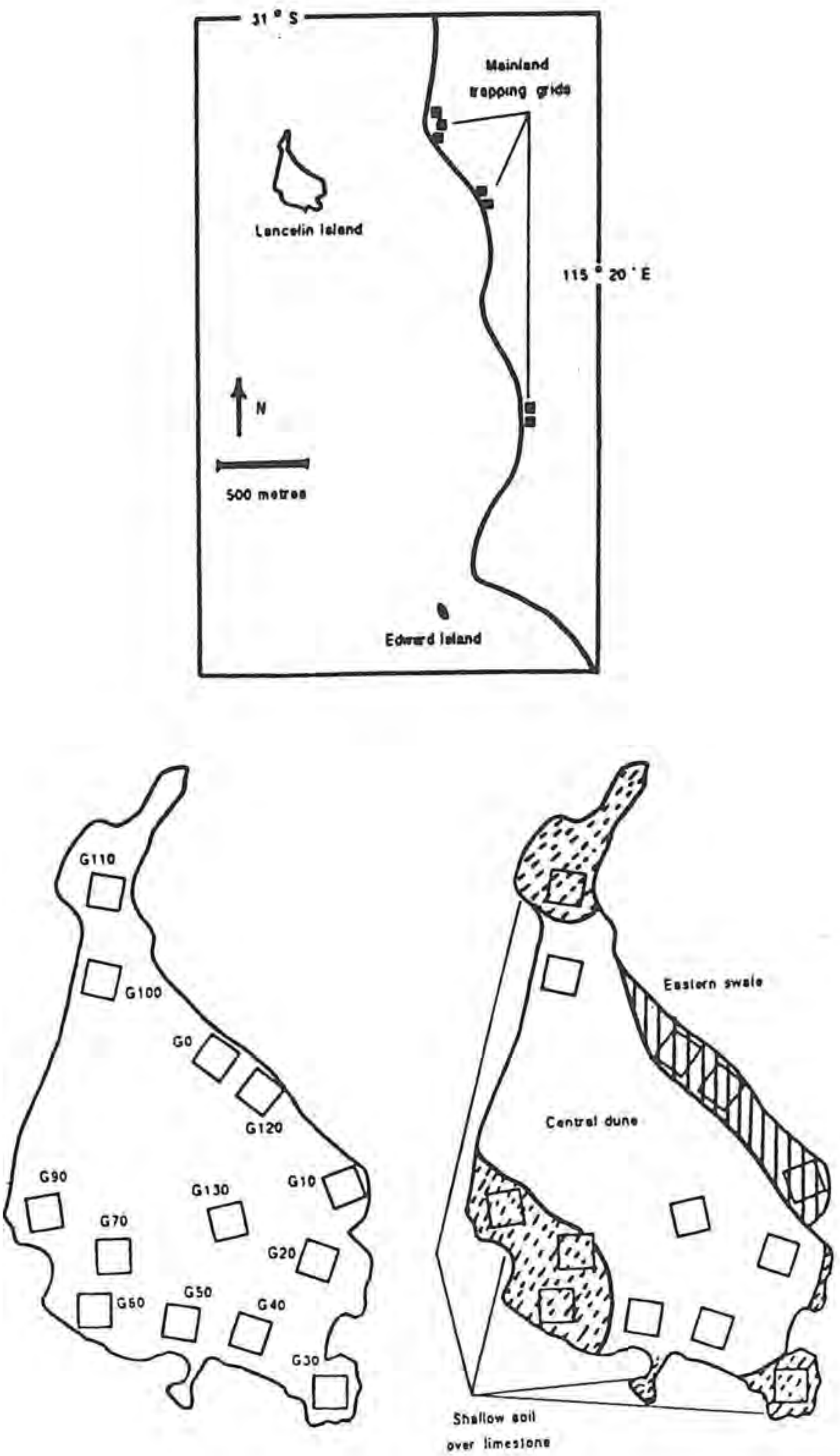


Figure 3. Maps of Lancelin and Lancelin Island.

The vegetation on the Island is generally less than 1 m high, although a few taller shrubs occurred in the eastern swale. Keighery and Alford (in prep) list the Island's plant species. Plants fall into three main categories: woody perennial shrubs, perennial trailing plants, and winter annuals. Over the last twenty years (the introduced winter annual) rye-grass (*Lolium ridgium*) has become established in all vegetation types. It has replaced much of the original vegetation on the shallower soil over limestone. The introduced ice plant (*Mesembryanthum crystallinum*) also occurred in all vegetation types, but only formed extensive mats in the shallowest soils over limestone, where (presumably) soil depth limited the rye-grass.

Reliable rainfall occurs between late autumn and spring, and significant rainfall occurs in some years between late spring and early autumn. The prevailing winds blow from the south or south-west on an almost daily basis.

The Island is used by large numbers of breeding seabirds, mostly between spring and early autumn. The Silver Gull (*Larus novaehollandiae*) was the only common surface nesting seabird which used the Island for breeding during winter. The guano deposited by the seabirds is a major source of imported nutrients for the Island's plants and animals, and the bulk of the guano is deposited during the drier months between late spring and early autumn. Gillham (1961) discusses the impact of seabird guano on vegetation on SW islands.

On Lancelin Island, shearwaters and petrels dig nesting burrows. Burrows were were abundant on the large central dune, and common on the eastern swale and in limestone areas with a sufficient depth of soil. The birds move substantial amounts of sand during excavation, often burying surface litter and prostrate vegetation. Old and recently excavated burrows form a significant habitat component for the Island's terrestrial fauna.

The terrestrial vertebrate fauna of the Island consists of six skinks and one gecko (*Ctenotus fallens*, *Ctenotus lancelini*, *Cyclodomorphus celatus*, *Egernia multiscutata bos*, *Lerista lineopunctulata* , *Morethia lineoocellata*, and *Strophurus spinigerus*). The gecko, *S. spinigerus* was not sighted during this study.

Two bird species were seen foraging regularly on the Island: the rock parrot (*Neophema petrophila*) took seed from a range of Island plants, and the banded rail (*Rallus philippensis*) foraged amongst vegetation and also along the waterline. Casual inspection of the (abundant) boluses from the banded rails indicated some individuals foraged away from the Island, and that they ate a wide array of plant and invertebrate material. The rails were the only (non-reptilian) predator which was considered to be a potentially significant predator of skinks, since the rails were observed scratching through litter and turning it over. Small groups of rock parrots were frequently seen flying between the Island and the adjacent mainland. Kestrel were sighted and appeared to nest on the Island. An owl (*Tyto alba*) was sighted once, and freshly stripped seabird carcasses frequently appeared overnight.

2.3 Climate during the study

The average monthly temperatures and rainfall at Lancelin are shown in Table 1, along with the actual rainfall totals for months between 1990 and 1995. The Lancelin recording station is right on the coast, and less than 2 km from the Island.

Table 1. Lancelin climate. The mean monthly minimum and maximum temperatures and mean monthly rainfall for Lancelin. The total monthly rainfall for the period 1990-95 is also listed.

	Temperature		Rainfall						
Month	Min	Max	Mean	1990	1991	1992	1993	1994	1995
Jan	17	29	10	101	-	5	-	-	-
Feb	18	30	15	5	24	67	8	-	-
Mar	16	28	14	15	10	46	13	1	10
Apr	14	25	35	34	30	38	7	2	22
May	12	22	88	83	68	43	90	132	82
Jun	11	20	135	92	212	126	96	77	124
Jul	10	19	131	169	128	105	93	101	175
Aug	10	19	94	82	54	187	85	92	49
Sep	10	21	54	39	61	56	58	37	49
Oct	12	23	31	34	30	24	22	20	61
Nov	14	24	24	7	69	39	21	2	15
Dec	16	27	8	2	34	7	2	8	6
Rainfall:	annual total		638	665	722	743	496	472	593
	total: Jan-Apr		74	155	65	155	28	3	32
	total: Sep-Dec		116	83	195	125	104	66	132

Inspection of the rainfall during 1990-95 shows that 1993 and 1994 were dry years with annual rainfall only about 75% of average. During the season of relevance to *C. lancelini* (October-March) the average rainfall was 102 mm. Between October 1993 and March 1994 only 47 mm fell, and between October 1994 and March 1995 41 mm fell. Thus, during the study period, rainfall recorded during late-spring-early-autumn periods (when *Ctenotus* on Lancelin Island were most active) was only 40-50% of average. In summary, the study was undertaken during a period of very dry conditions.

2.4 The Lancelin Study Area

To obtain an estimate of the relative abundance in the mainland *C.lancelini* population, trapping using the same trap design and schedule as on Lancelin Island was undertaken on the Lancelin foreshore reserve during November and December 1995. The location of mainland trapping grids is shown in Figure 3.

The main habitat characteristics which differed between the Island and the adjacent mainland foreshore were: the absence of breeding seabirds on the mainland; a more diverse reptile fauna than on the Island; the extensive southern and western aspects of the small coastal dunes and the associated absence of sites with protected northern or north-eastern aspects (which were present on the Island). The common components of vegetation were floristicly and structurally similar, though the mainland sites had an *Acacia* component which was rare on the Island.

3. METHODS

All data collection was undertaken by one person (the author).

3.1 Trapping

Traps were plastic containers with a depth of 19 cm and were square in cross-section with a width of 18 cm (*4 litre 'Liver Pails'* with lids, supplied by *Silverlock* , Cannington). Each trap had a plywood cover of 30 x 30 cm, which covered the pit when traps were open or closed. Fences were not used because of disruption associated with burrows and seabirds. Also, the use of fences in this study/habitat would have probably biased the capture results towards lizards which moved across the more open areas (i.e. away from those which forage 'under things'). Traps were kept clean (i.e. with no soil in them) to facilitate counting and release of invertebrates (to minimise harvesting of 'lizard food' near pits and ant-foraging of dead invertebrates) and the collection of skink faecal pellets.

Each trapping grid consisted of nine traps spaced 10 m apart, so the eight outer traps were on the edge of a square of 20 m x 20 m. Grid orientation was variable, and in some habitat types grids were somewhat skewed to fit the whole grid into a single (major) habitat type, or to avoid larger patches of rock. Traps were numbered from 1-9, with trap 1 being designated as the most southwestern corner pit on the grid.

Grids were numbered from G0 (pits 1-9) to G130 (pits 131-139). Five additional pits (GA, pits A1-A5) were placed within G0, and a further 6 pits were placed 20 m north of G0 during November 1995 to collect (unmarked). *C.lancelini* for captive breeding and genetic studies.

Thirteen grids (Figure 3) were used during the course of the study, though not all were used for the whole period. Initially six grids were to sample the limestone habitat, with two grids in each of the other major habitat types (central dune, eastern foredune). One additional grid was added to each of the sandy habitat types when it was found that *C.lancelini* was not restricted to rocky areas. Grids and pits were placed without any reference to topography. Grid 80 was planned for the limestone habitat, but pits were not put in.

Some pits were not used in all trapping sessions. The pits were frequently disturbed by island visitors, and sometimes stolen. Also, some pit locations 'disappeared' into holes when the adjacent surface collapsed into large seabird burrows. [The surface was most unstable from January until the roots of the winter grasses grew enough to strengthen the 'roofs' of burrows (April or May, depending on the arrival of the winter rains).] Some pits adjacent to the eastern beach were also lost or moved as a consequence of erosion of areas which were vegetated at the commencement of the study.

During cooler months with lower capture rates, pits were cleared only once each day. When capture rates were higher pits were cleared 2-3 times each day.

The traps were opened for periods of 2-5 days at a time. Between January 1994 and April 1995 trapping was conducted 2-3 times each month, except for June 1994, when only one trapping period was undertaken. Trapping of similar frequency was undertaken from September-December 1995.

Each trapping period is referred to as Trip number, and the dates were as follows: **Trip 1**: 22-23 Dec, 1993; **T 2**: 17-20 Jan 1994; **T 3**: 29-31 Jan; **T 4**: 4-6 Feb; **T 5**: 14-16 Feb; **T 6**: 25-27 Feb; **T 7**: 9-11 Mar; **T 8**: 29-31 Mar; **T 9**: 9-12 Apr; **T 10**: 19-21 Apr; **T 11**: 27-29 Apr; **T 12**: 12-13 May; **T 13**: 27-28 May; **T 14**: 5-6 Jun; **T 15**: 3-4 Jul; **T 16**: 16-18 Jul; **T 17**: 7-8 Aug; **T 18**: 16-18 Aug; **T 19**: 3-5 Sep; **T 20**: 18-22 Sep; **T 21**: 8-12 Oct; **T 22**: 18-19 Oct; **T 23**: 29-31 Oct; **T 24**: 12-15 Nov; **T 25**:26-30 Nov, **T 26**: 10-13 Dec, **T 27**: 22-24 Dec; **T 28**: 8-10 Jan 1995; **T 29**: 23-25 Jan; **T 30**: 2-4 Feb; **T 31**: 16-18 Feb; **T 32**: 3-4 Mar; **T 33**: 29-31 Mar; **T 34**: 11-13 Apr; **T 35**: 19-22 Apr; **T 36**: 22-25 Sep; **T 37**: 14-16 Oct; **T 38**: 21-23 Oct: **T 39**:28-30 Oct; **T 40**: 9-11 Nov; **T 41**:14-17 Nov; **T 42**: 22-26 Nov; **T 43**: 1-5 Dec; **T 44**: 18-21 Dec 1995.

Trapping weather

Managing climate monitoring equipment in what amounted to a 7 ha adventure park for wandering kids during school holidays was out of the question. (Adults settled on the beaches; kids off to explore.) Nevertheless, I collected some grid temperatures during summer '94 which showed that shaded air temperatures at knee height could vary up to about 8 °C between habitat-types at similar times.

Although no technical equipment was used, I acquired a vast amount of personal data about weather and substrate thermal conditions. I sat on the ground to process lizards, and sampled (more exposed area's) substrate temperatures. When the grids were busy, I often processed whilst skinks were most active, and walked the Island and all grids 2-3 times each day. The short vegetation ensured I repeatedly sampled the wind in most parts of the Island.

3.2 Lizards

Initially all lizards were individually marked with toeclips. The numbering system used is shown in Table 2.

Table 2. The toeclip numbers assigned to each digit.

Toeclip number	Digit	Toeclip number	Digit
1	left manus V	10	left pes V
2	" IV	20	" IV
3	" III	30	" III
4	" II	40	" II
5	" I	50	" I
6	right manus I	60	right pes I
7	" II	70	" II
8	" III	80	" III
9	" IV	90	" IV
200	" V	100	" V

As the study progressed the large number of lizards in some groups required that some groups be bulk-numbered. Bulk numbering was used most extensively in *C.fallens* , but some *C.lancelini* were bulk-numbered during late 1995. Some numbers used were not real (counting) numbers, and some lizards were known by numbers which reflected real toe loss (if 3 or more toes were off). Such numbers were handled by listing each toe off. As the study progressed it became apparent that some lizards marked with a single toe off could be confused with unmarked lizards with natural toe loss. This was much rarer amongst lizards numbered with toeclips on 2 or 3 toes. During editing of the capture records recaptures identified on the basis of toe clips in the field were confirmed or rejected by comparison of gender, the pattern of tail breaks, and any obvious scarring or limb loss and the location and dates of captures.

The minimum amount of data collected for each capture included the lizard species, toe number, trap number and one of three age-classes (juvenile, subadult, adult). These data could be recorded even if the lizard was dropped before it's toes had been checked. During 1993-1994 most trapped lizards had the following data recorded: species, toe number, weight, snout-vent length (SVL), tail length (TL) and position of old regrowth points, basal tail diameter (TD: lateral width, just posterior to the vent) and gender (for adults only). Supplementary measurements were taken from some lizards, including head length and width and hindlimb length (HLL: from body to tip of digit IV). Some lizards which were caught daily (invariably *C.fallens*) had full recording for only the first capture each trip.

Full extrusion of the hemipenes was avoided in *Ctenotus* and *M.lineoocellata* , which (as adults) could be sexed with reference to the shape of soft tissue around the vent. In males of these species the tissue margin anterior to the vent and hemipene apertures was well developed and muscular, and it formed the anterior surface of a conical cavity with the vent opening at it's (dorsal) base. In females, the anterior tissue margin was much less developed, appearing as a soft but prominent fold, and the vent was clearly visible, and flush with the surrounding soft tissue rather than in the base of a cavity. These differences were not clearly apparent in *C.celatus* and *E.m.bos*, which could only be reliably sexed by partial eversion of the hemipenes. No attempt was made to sex juveniles, since it was judged that associated tail-loss might influence condition / mortality. Inspection of subadult *C.fallens* indicated the differences used to sex adults were probably secondary sexual differences, since the male morphology developed with increasing body-size. Females with their body noticeably distended were assumed to be carrying eggs or young.

Faecal pellets were collected opportunistically from pits which had had only one species of lizard in them since last clearing. Faecal pellets were generally very rare, and were usually only obtained from lizards which spent the night in a pit during November-December.

Three age-classes were recognised for lizards: adult, subadult and juvenile. 'Juvenile' is used herein to refer to the smallest lizards of each species. Juveniles which survived their first winter are called subadults (no juvenile Island lizard grew fast enough to reach breeding status for the first summer breeding season following hatching). 'Adult' refers to individuals judged to be within the size range of breeders, as ascertained during the 1994-95 summer. In the assessment of captures of the five commonly caught skinks only two age-classes were used: juvenile and adult. Reproductively immature subadults of the two *Ctenotus* species could not be confidently recognised (due to the rarity of young surviving from the '94 hatchings, and older subadults / small adults with growth impeded from repeated, significant events of tail loss).

3.3 Invertebrates

The relative abundance of invertebrates was considered to be a habitat variable which might influence lizard activity or relative abundance. An indicator of the relative abundance or activity of invertebrates could be generated from records of the presence of invertebrates caught in pits. The procedure used was as follows. Pits were cleaned at the commencement of a 24 hour period during each trapping trip, and the captures of invertebrates with a length of 3 mm or more recorded for each pit during that period. (Early in the study pits were checked at dawn and dusk, and these records showed that about 95 % of trapped invertebrates were trapped during darkness).

Less common invertebrates (spiders belonged to this category with relatively high species diversity but low abundance) were identified at higher taxonomic levels only, but some common taxa were recognised at lower taxonomic levels. Several species of tenebrionid beetles were commonly caught, but the individual species were of similar size and were not distinguished for the record. Two species of earwigs were caught in pits, and were separated for recording purposes since they differed substantially in size and relative capture rates (*Gonolabis michaelseni* (Dermaptera: Labiduridae) was large and common, the other was tiny and rare).

3.4 Habitat Characteristics

Brief descriptions of the topography and vegetation of each grid were recorded (Appendix 1). Since no trends in variation of *C.lancelini* appeared to be related to measurable aspects of vegetation, such characteristics were not quantified.

Estimates of the dominant slope and aspect for each grid were quantified by estimating, for four points (N, S, E, W) each 15 m from the central pit, the vertical displacement of the points relative to the central pit. Hence, on a grid with a steep, prevailing south-facing slope, the north point might be at + 1m, and the southern point at -1m.

Meaningful measurements of microclimatic variables would have been a wonderful asset to this study, but are labour and technology intensive to collect, and hence were beyond the resources allocated for the project.

The extent of protection/exposure of each grid from the prevailing S-SW winds was quantified by ranking grids on the basis of the author's ranking of her own relative discomfort associated with the absence (rank 1) or excess of wind encountered on each grid.

3.5 Capture rates

Capture rates were derived for a particular groups (adults of each species, or juveniles, etc) for specified periods or areas as follows:

$$\text{capture rate} = \frac{\text{total number of captures}}{[(\text{number of open pits}) \times (\text{number of days pits were open})]}$$

The denominator indicates the amount of trapping effort required to obtain the captures. For convenience, the capture rates given herein are in units of captures per 100 trap-days (abbreviated in text as 100TD).

The capture rates derived using the Island capture results measured the frequency at which lizards encountered and subsequently entered a pit. Since traps lacked fences, they were effectively point monitors of the relative level of usage of the trap-site by the local lizard population. Trap-sites (or grids) with the highest frequency of usage represent the most popular habitat types and those with the lowest capture rates represent the least popular habitat types. Relative capture rates can thus be considered as a quantitative indicator of relative habitat quality in different habitats (by employing the assumption that the relative abundance of a species is low in low-quality habitat and highest in high-quality habitat). Comparison of variation in habitat quality (as indicated by capture rates) facilitates identification of major habitat characteristics associated with high quality habitat.

Capture rates given in the results section on captures of all species between May '94 and April '95 were derived for both adults and young of each species in each calender month (sum of all captures on all grids within the month / effort on all grids for each month) and for each grid (sum of captures in all months on each grid / effort on each grid in all months). 'Sum of all captures' refers to all captures in a relevant group (e.g. all juvenile *C.lancelini* caught in January, or all adult *C.fallens*)

The capture rates used in the *C.lancelini* results section were derived for each subgroup (males, females, subadults and juveniles) from the number of captures on each grid or each trip (tables in Appendix 2). The period of captures used for the 'adult-season' in '94 and '95 was defined as extending from the latest September trip until December 31. Trips either side of the period had generally lower capture rates, and included worse weather (cool and cloudy in August-September, hot easterlies from January on). The overall average capture rate for each adult season was derived by averaging the trip capture rates (to minimise the effect due to variation in effort between months).

Subadult capture rates were derived from captures during the same period as used for adults. Juvenile capture rates were derived from trips between January and April. Most young probably emerged by mid-March, and captures during this period offered the best view of where young emerged.

Patterns of captures of adults during the '95 adult season were further investigated using a subset of the season's captures which were recorded for the 23 individual trapping days which had pits open from dawn-dusk. Effort was equal for each day, so the data was expressed as numbers of individuals caught on each day. The data about captures of adults per pit (Table 6) used only the records for the 23 entire trapping days.

The *C.lancelini* capture rates were used to assign grid areas to one of two classifications relating to the rate at which the Island *C.lancelini* population used the grid. Grids which caught at least 7 adult *C.lancelini* /100TD in both breeding seasons were classified as high usage grids, and grids with lower capture rates were classified as low usage grids.

3.6 Population estimates

The data collected about captures and recaptures of *C.lancelini* proved to be unsuitable for reliable population estimates, primarily due to low recapture rates and females moving into incubation areas. In the '94 season few adults were marked before the season started, and in '95 captures of males were too rare to provide reliable data. Density estimates were equally problematic, because the area which each trap sampled was unknown. The numbers generated for density and population size and included in results may be roughly correct, but they may also be way out: there was no independent means to assess confidence limits. Further, there was sufficient evidence to suggest population size may have differed substantially between years due to the dry conditions of the study period. The estimates were generated for this report only because land managers need some estimate.

With such awkward data the derivation of densities or population estimates depends on trying to minimise the effects of the assumptions which any technique requires. Two major assumptions were used:
(i) the sample area was treated as though the grids were contiguous
(ii) the area sampled by the nine pits in each grid was 900 m^2.
The first assumption would lead to an overestimate (due to immigration along grid edges where those edges were suitable habitat). The second assumption would lead to an underestimate, because each pit

effectively sampled an area much less than 100 m^2.

A conservative approach which derives population estimates for minimum numbers provides the best option to ensure that the derived estimate is on the low side of the true value.

4. RESULTS

4.1 The Lancelin Island Lizard Community

Results presented in this section were derived from trap captures on thirteen Lancelin Island grids (Figure 3) undertaken during each month of a complete annual cycle between May 1994 and April 1995. Five skink species were regularly trapped during this period (*Ctenotus lancelini*, *Ctenotus fallens*, *Morethia lineoocellata*, *Egernia multiscutata bos*, *Cyclodomorphus celatus*). A single *Lerista lineopunctulata* was trapped, and this species had not been previously recorded from Lancelin Island. The gecko (*S. spinigerus*) was not trapped or sighted during any part of the study. The five commonly caught species are referred to by codes in most tables and some figures: CF: *C.fallens*; CL: *C.lancelini*; ML: *M.lineoocellata*; EB: *E. m.bos*; CC: *C.celatus*.

Capture rates for each of the five species caught regularly were derived from 1075 skink captures recorded during a total of 6669 trapdays.

Variation in Capture Rates

Seasonal variation in species capture rates

Patterns of seasonal variation in capture rates differed between the species (Table 3).

Table 3. Monthly capture rates of adults (A) and juveniles (J) of the five commonly caught skinks derived from trapping on thirteen Lancelin Island grids between May 1994 and April 1995.

		CL			CF			ML			EB			CC		
		A	J	All	A	J	All	A	J	All	A	J	All	A	J	All
1994	May	-	-	-	-	1.3	1.3	2.8	1.7	4.5	0.2	-	0.2	-	-	-
	Jun	-	-	-	-	-	-	0.4	-	0.4	-	-	-	-	-	-
	Jul	-	-	-	-	-	-	0.2	-	0.2	1.2	0.2	1.5	-	-	-
	Aug	0.2	-	0.2	-	-	-	1.5	-	1.5	0.2	0.7	1.0	-	-	-
	Sep	3.4	-	3.4	1.6	-	1.6	2.4	-	2.4	1.9	0.1	2.0	0.1	-	0.1
	Oct	4.5	-	4.5	8.1	-	8.1	2.4	-	2.4	2.0	0.1	2.1	1.3	-	1.3
	Nov	11.4	-	11.4	15.0	-	15.0	2.3	-	2.3	0.9	-	0.9	0.8	-	0.8
	Dec	3.5	-	3.5	17.6	-	17.6	2.5	-	2.5	0.7	-	0.7	0.7	-	0.7
1995	Jan	1.8	4.2	5.9	8.1	0.7	8.7	1.3	0.9	2.2	-	-	-	-	-	-
	Feb	0.9	2.7	3.5	4.9	8.9	13.7	0.4	1.1	1.5	-	-	-	0.7	-	0.7
	Mar	-	1.5	1.5	2.1	8.5	10.6	1.5	2.5	4.0	0.6	-	0.6	-	-	-
	Apr	0.2	1.8	2.0	1.6	10.8	12.4	1.6	2.0	3.6	1.1	0.7	1.8	-	0.2	0.2
Total no of captures		210	47	257	413	142	555	119	42	161	62	9	71	29	2	31

The two *Ctenotus* shared a similar pattern with peak capture rates in November or December and very low capture rates during May-August. *E.m.bos* and *M.lineoocellata* were caught in all seasons. Captures of *M.lineoocellata* showed a prominent autumn peak (43% of all *M.lineoocellata* captures in March-May) and another less prominent period of higher capture rates during September-January (also 43% of all *M.lineoocellata* captures). *E.m.bos* was rarely caught during December-March (only 12% of all *E.m.bos* captures). *C.celatus* was caught most frequently during late September-December and rarely during other months.

Captures of young *E.m.bos* and *C.celatus* were too few (9 young *E.m.bos* and 2 young *C.celatus*) to draw any conclusions about seasonal patterns in reproduction of these two live-bearers. Capture rates of adults of the three oviparous species (*C.fallens*, *C.lancelini* and *M.lineoocellata*) showed similar seasonal patterns (Figure 4) with adult capture rates peaking prior to the to first appearance of young.

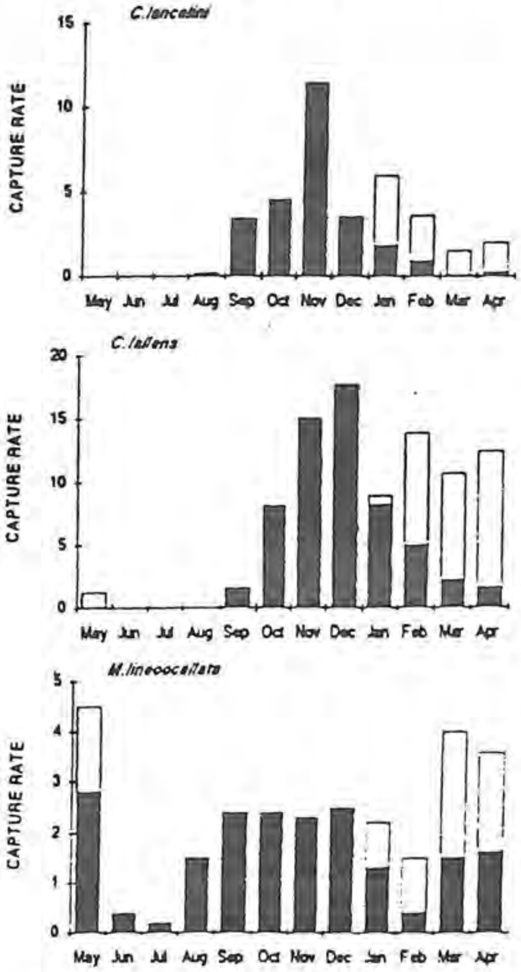


Figure 4. Monthly capture rates of adults (solid) and juveniles (open) on thirteen Lancelin Island grids for (a) *C.lancelini*, (b) *C.fallens* and (c) *M.lineoocellata* (from Table 3).

Young *C.lancelini* were first caught in January, when 41% of all captures of young were recorded. Only 2% of all young *C.fallens* were caught in January, with capture rates for February-April being much higher. Comparison of the seasonal patterns of both *Ctenotus* indicated that, while the overall seasonal patterns were similar, *C.lancelini* tended to be about one month ahead of *C.fallens* in the season's first captures, the peak of adult capture rates and the first captures of juveniles.

Geographic variation in species capture rates

Patterns of seasonal variation in capture rates differed between the species (Table 4).

Table 4. Grid capture rates of adults (A) and juveniles (J) of the five commonly caught skinks derived from trapping on thirteen Lancelin Island grids between May 1994 and April 1995.

	CL			CF			ML			EB			CC		
	A	J	All	A	J	All	A	J	All	A	J	All	A	J	All
G0	5.9	0.8	6.8	15.4	1.9	17.3	3.6	0.2	3.8	1.1	0.4	1.5	0.6	-	0.6
G10	1.4	1.4	2.7	17.6	4.5	22.0	1.0	-	1.0	2.5	-	2.5	-	-	-
G20	5.5	0.4	5.9	2.7	0.8	3.5	1.8	0.4	2.1	1.0	-	1.0	-	-	-
G30	0.2	-	0.2	1.4	1.2	2.6	0.6	2.2	2.8	-	-	-	0.2	-	0.2
G40	1.0	0.4	1.3	1.1	0.8	1.9	2.7	0.6	3.2	0.8	-	0.8	-	-	-
G50	1.7	1.1	2.9	3.0	2.9	5.9	2.3	0.6	2.9	1.0	-	1.0	0.2	-	0.2
G60	0.2	0.6	0.8	1.0	2.1	3.1	0.4	0.8	1.1	-	-	-	0.8	0.4	1.1
G70	7.3	1.1	8.4	4.2	3.6	7.8	2.1	0.2	2.3	0.2	-	0.2	1.1	-	1.1
G90	0.6	0.6	1.2	3.9	3.7	7.7	1.8	0.4	2.2	0.2	-	0.2	0.2	-	0.2
G100	2.8	0.4	3.3	4.1	2.4	6.5	1.8	0.4	2.2	0.6	-	0.6	0.4	-	0.4
G110	2.8	0.4	3.2	4.9	1.7	6.6	3.6	1.3	4.9	0.6	-	0.6	1.7	-	1.7
G120	7.9	1.5	9.5	18.5	1.7	20.3	0.8	0.2	1.0	2.5	1.4	3.9	0.4	-	0.4
G130	3.8	0.4	4.2	3.4	0.4	3.8	1.0	1.0	1.9	1.7	-	1.7	-	-	-

Captures of *C.celatus* (Table 4) were largely restricted to rocky limestone areas (72% of the year's *C.celatus* captures were from rocky grids). The four other species were caught in all habitats sampled. Captures of *E.m.bos* suggested its distribution on Lancelin Island was more patchy than *C.lancelini* , *C.fallens* and *M.lineoocellata* . Only 2% of *E.m.bos* captures were from the four southern rocky grids (G30, G60, G70, G90), but 4% of *E.m.bos* captures were from the only northern rocky grid (G110). 39% of *E.m.bos* captures were recorded from the two adjacent grids at the northern end of the eastern swale (G0 & G120).

C.lancelini , *C.fallens* and *M.lineoocellata* were caught on all grids. For *M.lineoocellata* , the highest and lowest grid capture rates differed by a factor of 5. *Ctenotus* grid capture rates were more variable, with *C.lancelini* and *C.fallens* capture rates differing by an order of magnitude between grids with the highest and lowest capture rates for each *Ctenotus* .

The variation in *Ctenotus* capture rates is the major component of the variation in skink capture rates between grids. Higher *Ctenotus* capture rates were recorded on grids which had a (roughly) northeastern aspect and a rise of at least several metres to their south or southwest. During the spring-early summer peak of adult *Ctenotus* activity these areas were warmer and less windy (usually uncomfortably sol) than areas which were flat, high, or had southern or western aspects. The trend for high *Ctenotus* capture rates to be associated with site topography of a protected northern aspect appears independent of substrate type. (Higher *Ctenotus* capture rates on G70, which had shallow soil over limestone, and on G0 and G120 which had deeper white sand).

Species Trappability

A subset of the capture records for May 1994-April 1995 was used to obtain a numeric indicator of the relative level of trappability of each of the five species (Table 5) for the particular array of traps used in the study. The subset included only adults and subadults (which had survived their first winter) which were individually marked with toeclips on two or more toes. For the purposes of Table 5 the first capture was an individual's first capture during the sampling period (regardless of capture records prior to May 1994).

An indicator of the relative abundance of individuals of each species within the sample area was derived by dividing the total number of captures of adults and subadults (in Table 3) by the mean number of captures per individual (Table 5). For the subset of captures used in Table 5 the total of 610 lizard captures was accumulated from 467 individuals and there was an average of 0.76 individual lizards per capture. Thus, the total of 833 captures of adult lizards (recorded in the full 12 month period) would presumably require a minimum of 637 adult lizards within the sampled area. Using a similar process for captures of each species indicates that about 37% of the adult and subadult skinks in the sampled area were *C.fallens*, 30% were *C.lancelini* , 19% were *M.lineoocellata* , 8% were *E.m.bos* and 5% were *C.celatus*.

Species Morphology

The size ranges based on SVL and body weight for each of the species are shown in Table 6.

Table 6. Summary data showing the size range (SVL in mm and weight in grams) of each of the five commonly caught skinks. The ratio of HLL / SVL indicates the relative length of the hindlimb. The weight and SVL data were derived from all of the season's captures. The HLL / SVL ratios were the mean ratio derived from a subset of 20 adults (10 males and 10 females). The weights given include variation due to variable degrees of tail-loss and the carrying of young by females.

	SVL		Weight		Adult
	min	max	min	max	HLL / SVL
CL	29	87	0.3	14	0.344
CF	32	102	1	24	0.381
ML	21	63	0.1	4.5	0.359
EB	39	97	1.5	27	0.392
CC	48	119	1.5	20	0.176

M.lineoocellata was much smaller than the other skinks. *C.fallens*, *E.m.bos* and *C.celatus* were of similar size, and *C.lancelini* was intermediate between the 3 larger species and *M.lineoocellata*.

The relative development of the hindlimb was quantified by comparison of it's length with an individual's SVL. *E.m.bos*, *C.fallens* and *M.lineoocellata* had relatively long hindlimbs (being 39%, 38%

and 37% of the SVL, respectively). The hindlimbs of *C.lancelini* were somewhat shorter (34% of SVL), and those of *C.celatus* were much shorter (18% of SVL) than the other 4 commonly caught skinks. Measurements of *L.lineopunctulata* from Lancelin Island were not available, but the species is characterised by reduction or absence of the forelimb, and reduction of the hindlimb, and is regarded as fossorial (Storr *et al.* 1981).

4.2 *Ctenotus lancelini* on Lancelin Island

Much of the available information about the population biology of *C.lancelini* on Lancelin Island is based on the documentation of relative capture rates, and on the data collected from captured lizards. Seven large tables given in Appendix 2 summarise most data used to calculate capture rates used in the following sections.

Variation in Capture Rates

Annual Variation in Capture Rates

C.lancelini was active from August-April (Figure 4). Most adults were caught between mid-September and mid-January. The November capture rate was more than double that for any other month. Juveniles were first caught in mid-January, and were active until April.

Capture Rates of Females and Males

Table 7 shows the numbers of females and males caught on each of the 23 days trapped (pits open dawn-dusk) during the 1995 season of adult activity (late September to December).

Table 7. The numbers of adult *C.lancelini* in 9 groups of animals caught during each whole day of trapping between late September and December, 1995. 84-86 pits were open on each day. Groups for females: **all females**: the number of females caught; **gravid females**: the number of females with moderate to extreme distension of the body cavity; **recaps old females**: the number of females caught which had been marked before winter 1995; **new females**: females which were not recognised as those marked on previous trips; **recaps of new females**: recaptures of females marked between September-December 1995: groups for males defined similarly.

1995	Females					Males			
Month Date	all fems	gravid fems	recaps old fems	new fems	recaps of new fems	all males	recaps old males	new males	recaps of new males
Sept: 23	3		2	1		1	1		
24	0					0			
Oct: 14	2		2			1		1	
15	4			4		2		2	
21	2			2		4	1	1	2
22	2		1	1		0			
28	1	1	1			3	1	2	
29	4	2		3	1	6	1	5	
Nov: 10	3	2		2	1	0			
11	5	4		5		0			
14	13	12	1	12		0			
15	7	6	2	5		1	1		
16	6	6	2	4		2		2	
17	5	5		5		0			
23	11	9	1	10		2		2	
24	10	9	1	7	2	2	1	1	
25	10	8		9	1	0			
Dec: 2	4	1	1	3		2	1	1	
3	3	2	1	1	1	1		1	
4	3	3	1	2		1		1	
18	2	1		2		1	1		
19	5	2	1	3	1	2	1	1	
20	2	2		2		0			
	107	75	17	83	7	31	9	20	2

The female capture rate peaked between November 10-30, when 87% of females caught were apparently gravid. The male capture rate peaked about one month earlier, between October 20-30. This indicates that captures of individuals involved in reproductive activities dominated the pattern of captures for *C.lancelini* , and suggests the possibility that such animals encountered traps more frequently than did non-breeding individuals. Also, it suggests eggs were carried for about 1 month, and that most females deposited eggs within a 2-3 week period.

Overall, 16% of the females caught were marked in previous seasons. Prior to November 10, 33% of captures were of previously marked females, but between November 10-20, 83% were new females. This suggests that some females moved into the trapping area during the egg-laying period.

During this sample period males accounted for 22% of all adult captures. (This would probably have been higher if there had been some trapping during good weather in early November.) Males marked in the previous season accounted for 29% of all males caught, which was much higher than female equivelent of 16%.

Trappability of Females and Males

Five hundred and twenty trap captures of *C.lancelini* were recorded prior to 1996. Twenty five females and 18 males were reliably identified and caught twice or more. Most recaptured adults (90 %) were caught only twice. One female was caught four times and three females were caught three times. Two males were caught three times.

The mean number of captures per individual for individuals caught twice or more provides the most reliable indicator of the relative level of trappability of the genders. The retrap females were caught on average 2.2 times each and retrap males were caught 2.1 times each.

There were hints (but no useful data) in the pattern of captures which suggested that heavily gravid females were more trappable than other individuals.

Capture Rates of Adults per Grid in 1994 and 1995

The capture rates for males and females caught on each grid between late September and December are listed in Table 8.

Table 8. Capture rates for each grid for adult female, male and all (females plus males) *C.lancelini* between late September and December 1994 and 1995.

	1994 capture rates			1995 capture rates		
Grid	female	male	all	female	male	all
G0	9.5	1.9	11.4	12.1	1.4	13.5
GA	11.5	1.5	13	13.2	0.8	14
G10	1.3	0.9	2.2	2.3	1.4	3.7
G20	3.8	7.3	11.1	4.6	2.8	7.4
G30	0.5	0	0.5	-	-	-
G40	0.4	1.3	1.7	1.9	1.4	3.3
G50	1.3	2.1	3.4	-	-	-
G60	0	0.4	0.4	-	-	-
G70	11.5	4.7	16.2	13.2	1.4	14.6
G90	0.4	0.9	1.3	0.6	1.3	1.9
G100	1.8	4.6	6.4	1	1	2
G110	3.4	2.6	6	0	0.5	0.5
G120	11.9	3.4	15.3	7.8	2.3	10.1
G130	3.4	3.8	7.2	2.3	0.9	3.2

C.lancelini was caught on all grids, but grid capture rates varied by up to a factor of 40 (0.4-16.2 *C.lancelini* / 100 TD). Females were easier to catch in 1995 than in 1994 (1.16 extra females / 100 TD in 1995), but males were harder to catch in 1995 (1.04 fewer males / 100 TD in 1995). Twenty percent of all captures (1994 fems + males + 1995 fems + males) were of males in 1994, and 11% of all captures were of 1995 males.

In both years, the female capture rate was high on four grids (G0, GA, G70 & G120). These grids had low or moderate male capture rates in 1994 and 1995. The highest male capture rate was recorded on G20 in 1994, when male captures were almost twice as common as female captures. In 1994, 42% of grids (6 of 14) had male capture rate ≥ female capture rate (G20, G40, G50, G60, G100 & G130), but in 1995, fewer grids (27%, 3 of 11; G90, G100, G110) had male capture rate ≥ female capture rate. These data show there was variation in the relative capture rates of the genders between grids, and between years.

Capture Rates of Adults per Pit in 1995

Captures of adults between late September-December 1995 were not evenly distributed between pits (Table 9).

Table 9. The number of captures of females (gravid and slender) and of males per pit between late September-December 1995. Pits which caught no adult *C.lancelini* are not listed.

		1995				
Grid	Pit #	all fems	slender fems	gravid fems	males	all
	1	3		3		3
	2	2	1	1	1	3
	4	2	1	1	2	4
	5	2	1	1		2
	7	14	4	10		14
	8	1	1			1
G0		24	8	16	3	27
	A1	1		1		1
	A2	1	1		1	2
	A3	8	1	7		8
	A4	2	1	1		2
	A5	2	1	1		2
GA		14	4	10	1	15
	14				1	1
	15	2	1	1	1	3
	17	3	2	1	1	4
G10		5	3	2	3	8
	21	1	1			1
	23	2		2	1	3
	25	3	2	1	2	5
	27				1	1
	28	3	1	2	1	4
	29				1	1
G20		9	4	5	6	15
	42	3	1	2		3
	45				2	2
	48	1	1		1	2
G40		4	2	2	3	7
	71	1		1		1
	72	2	1	1		2
	73	1		1		1
	75	7		7		7
	76	3	2	1	1	4
	77	7		7		7
	78	5	1	4		5
	79	1		1	2	3
G70		27	4	23	3	30
	101	1		1		1
	103				1	1
	104				2	2
	107	1		1		1
G100		2	0	2	3	5
	113				1	1
	121	1		1	1	2
	122	1		1		1
	124	7		7	1	8
	125	3	3		1	4
	126	1		1		1
	127	1		1		1
	128	2	1	1		2
	129				1	1
G120		16	4	12	4	20
	132				1	1
	134	1	1			1
	135	1		1	1	2
	136	1		1		1
	137	1		1		1
	138	1	1			1
G130		5	2	3	2	7

Forty five percent of all females caught during late September-December 1995 were caught in one of six pits (nos: 7, 75, 77, 78, 124, A3). Each of these pits caught ≥ 5 females and ≥ 4 gravid females. The single male captured in these pits represents 2% of adults caught in these pits during late September-December 1995.

The extremity of the trend for males to be apparently absent from the areas with prime thermal conditions (for eggs, and hence probably adults) suggests that social factors may influence local abundance. The trend for females to exclude males is probably an artefact of the species sexual dimorphism. The underlying behaviour which seems most likely to explain the apparent social factors may be that smaller *C.lancelini* tend to avoid larger *C.lancelini* .

The six pits (7, 75, 77, 78, 124, A3) represent 12% of the pits which caught at least one adult *C.lancelini* , or 7% of all pits used during late September-December 1995. Although the array of grids was not strictly randomised, an estimate that the 'best' 10% of trapsites for females caught nearly half of all females caught indicates that these 'best' sites were relatively rare and used by many females.

Capture Rates of Young in 1994 and 1995

Capture rates for young *C.lancelini* caught on different grids are shown in Table 10.

Table 10. Capture rates of juveniles (J) on each grid between January and April 1994 and 1995, and of subadults (SA) between September and December 1995. No subadults were caught in 1994. (G120 and G130 were not used until March 1994).

Grid	1994 juvenile capture rate	1995 juvenile capture rate	1995 subadult capture rate
GO	3.7	6.0	0
GA	4.1	9.2	0.8
G10	0	3.9	0
G20	0.4	1.3	3.2
G30	0	0	-
G40	0	2.7	0
G50	0.9	2.7	-
G60	0	2.0	-
G70	2.7	4.7	0.5
G90	0	2.0	0.6
G100	0	0.9	1.5
G110	0	1.3	0.9
G120	0	5.4	0.5
G130	0.9	1.3	0.5

In 1994, juveniles were caught on 50% grids (6 of 12), and in 1995 on 93% of grids (13 of 14 grids). In 1995 juveniles were about 3.5 times easier to catch than in 1994.

Eleven main grids were used both seasons (G0, G10-70, G90-110). During the 1994 season, when there were few captures of juveniles, 85% of those caught between January and early March came from two grids which had been very popular grids for gravid females. In 1995, juveniles were caught more frequently than in 1994, and 41% of those caught January and early March came from G0 and G70. In both years G0 had 7-10 % more juvenile captures than did G70.

No subadults were caught during late 1993 or during 1994. In 1995, subadults were caught on most grids (8 of 11), but on G20, subadults were caught twice as often as on the only other grid which caught more than one subadult *C.lancelini* /100 TD (G100). In 1994, G20 and G100 both had a high male capture rate and a female capture rate about half that of the male capture rate. In 1995, when the subadults were caught, the male capture rate for the 2 grids (G20 and G100) was much lower than it had been in 1994.

The minimum difference between the number of subadults caught in 1994 and 1995 can be estimated by supposing that one (rather than none) *C.lancelini* had been caught in the 1994 season. Using this supposition the subadult capture rate for 1995 was at least 18 times greater than that for the 1994 season.

The subadults caught between September and December 1995 weighed an average of 2.6 g, and individuals ranged in size from an SVL of 42 mm and weight of 1.3 g to 63 mm and 4 g.

Body Condition of 1995 Hatchlings

Three periods during the 1995 season had a useful number of captures of juveniles within a short period (1-2 weeks) (Table 11).

Table 11. Body measurements, and a numeric indicator of body condition (TD / SVL x 1000) for juveniles caught during the 4th, 10th, 15th and 17th weeks of 1995.

		Week				
Body measurement		4	10	15	17	15 & 17 pooled
SVL	mean	33.4	33.8	35	38.2	36.9
snout-vent	SD	1.60	1.78			3.00
length	n	20	11	4	6	10
	range	29-35	31-37	32-37	35-41	32-42
TL	mean	56	54	63.3	60.6	61.8
tail	SD	10.00	15.32			16.16
length	n	20	11	4	6	10
	range	25-63	23345	45-71	28-83	45-83
WT	mean	2.4	2.1	2.5	2.8	2.7
weight	SD	0.21	0.33			0.36
	n	20	10	4	6	10
	range	1.9-2.8	1.6-2.7	2.3-2.9	2.4-3.3	2.1-3.3
TD	mean	0.7	0.5	0.8	0.9	0.8
tail	SD	0.12	0.18			0.24
diameter	n	20	11	4	6	10
	range	0.4-0.9	0.3-0.8	0.5-1.0	0.6-1.3	0.5-1.3
TD / SVL	mean	19.7	15	21.9	22.8	22.5
x 1000	SD	2.90	5.02			4.84
	n	20	11	4	6	10
	range	16-26	.9-23	16-27	17-31	16-31

SVL and TL showed very little change during the period, but TD, WT and TD / SVL decreased. Between weeks 4 and 10 the averages of three body variables fell: TD fell by 28%, WT fell by 12% and TD / SVL fell by 25%. By weeks 15-17, the averages for the three body variables were higher than in week 10: TD had risen by 60%, WT had risen by 28% and TD / SVL had risen by 46%. By weeks 15-17, young *C.lancelini* were, on average, larger than in week 4. The increase in the maximum SVL from week 4 to week 17 suggests that a few individuals were able to grow throughout this period of general decline.

The only young *C.lancelini* measured twice in different parts of the season showed a similar pattern of change to body measurements. The SVL and TL were similar when measured in week 5 and week 10 (wk 5: SVL 34 & TL 61 mm; wk 10: 35 & 60 mm), but TD fell from 2.1 to 1.7 mm, and weight fell from 0.6 to 0.5 g.

Rainfall appeared to be the factor which prompted change from a trend of decrease to one of increase in body weight and condition. The first substantial amount of rain during 1995 came late in week 14 and the week 15 trip was three days after the rain (late March). Data from the few 1994 captures of young shows a pattern which is consistent with the general 1995 trends, but the sample size is small. In 1994 there was no substantial rainfall until May, and no subadults were caught in the following spring.

Adult SVL Frequency Distributions

The subset of capture records for adult *C.lancelini* from late September-December in 1994 and 1995 provide size class data describing the population structure in different areas of the Island (Table 12).

Table 12. Frequency distributions based on SVL for adult female and male *C.lancelini* caught during late September-December 1994 and 1995. Individuals were assigned to one of two classifications based on relative grid capture rates: captures from G0, GA, G20, G70 & G120 were assigned to high usage grids (HUG) and captures from other grids were assigned to low usage grids (LUG).

	1994 females			1995 females			1994 males			1995 males		
	HUG	LUG	all	HUG	LUG	all	HUG	LUG	all	HUG	LUG	all
SVL												
65								1	1			
66												
67							2	1	3			
68							2	2	4			
69							3	1	4		1	1
70							3	2	5		2	2
71	1		1				2	5	7	1	1	2
72	2		2				5	1	6		1	1
73	1		1				7	3	10		4	4
74	4		4				2	4	6	1		1
75	6	3	9		2	2	2	5	7	4	3	7
76	6		6	4		4	7	4	11	3	1	4
77	2		2	5		5	1	3	4	2		2
78	10	2	12	14	3	17	1	1	2	2	1	3
79	8	1	9	11	1	12		1	1	3		3
80	9	3	12	17	4	21						
81	8	3	11	14	3	17				1		1
82	13	2	15	9	1	10						
83	8		8	8	1	9						
84	7	3	10	5		5						
85	3		3	4	1	5						
86	3	5	8	3	1	4						
87	2		2									

The extent of sexual dimorphism in body-size is clearly indicated in the difference between the female and male size distributions.

The 1995 distributions for both females and males lack the smaller individuals which were represented in 1994. In 1994, 7% of females caught had an SVL ≤ 74 mm, but in 1995, the smallest female caught had an SVL of 75 mm. In 1994, 11% of males caught had an SVL ≤ 68 mm, but in 1995 all males caught had an SVL of ≥ 69 mm. These results indicate that an age-class of individuals which was present in the 1994 sample was absent in the 1995 sample.

Comparison of the size distributions for high-usage and low-usage grids hints at adults on low usage grids being somewhat smaller than those caught on high usage grids, but for females this may be an artefact of small samples from low-usage grids. In 1995 males on high-usage grids averaged an SVL of 76.3 mm (SD 2.145), and males from low-usage grids averaged 73.1 mm (SD 2.556).

Recruitment trends

Elucidation of trends relating to variation in annual recruitment depends on identification of age-classes present in any sample, unless data collection continues long enough to trace individuals from hatching to first breeding. The rarity of subadults during the first 20 months of this two-year study force any interpretation of the available data to be somewhat speculative.

The small adults caught in 1994 (but not in 1995) probably hatched in early 1992, when monthly rainfall for January-April (Table 1) was much higher than average. The absence of small adults in late September-December 1995 followed an apparent absence of subadults in 1994: these (absent) individuals probably hatched in early 1994.

These observations suggest that the survival of 1992 hatchlings to subadulthood was, relatively good. In comparison, the survival of young from hatchings in 1993 and 1994 was so low that the coresponding cohorts were not subsequently encountered as either subadults or small adults. The observations of declining body condition of juveniles detailed during early 1995 implicates juvenile mortality as one major biological parameter with the potential to limit adult abundance.

Movements of Recaptured Individuals

Males and females caught twice or more were usually caught in the same or adjacent pits (Table 13).

Table 13. The distance between subsequent captures of 43 individual *C.lancelini* recaptured after periods of 3 weeks to 2 years.

Distance between capture points	Females	Males	All
same pit	11	7	18
< 15 m	13	9	22
15-30 m	0	2	2
> 30m	1	0	1

The tendency to remain within a small area appeared to last a long time for some individuals (e.g. female L12 was caught 3 times: December 1993, November 1994, November 1995, in three adjacent pits, male L259 was caught 3 times: November 1994, January 1995, October 1995, in three adjacent pits). One female (L96) moved about eighty metres from pit 119 in September 1994 to pit 1 in January 1995. (Her identity was confirmed: two toes off and matching tail break scars).

The movement of L96 appears to be an example of the general trend for unknown gravid females move onto grids with high female capture rates between November 10-30 (when 'gravidity' of the female population is at a peak).

Only one juvenile was caught twice: five weeks separated the captures, and the individual was caught in the same pit on both occasions.

Reproduction

Courtship Behaviour

At 950 am on November 29, 1994, I sighted an adult *C.lancelini* amongst litter under an *Olearia* shrub which had a narrow strip of clear sand enclosing the litter below the shrub. Two adults were moving about the area (of about 1.5 sq m), and for much of the time I could sight only one. While I watched, the two emerged from an old storm petrel burrow, the follower clasping the leader's tail tip in its jaws. They moved about 30 cm, then one animal gently bit the other's body up and down its length for about 20 seconds. They separated and moved about 10 cm before I saw them lying side-by-side. They stayed that way for about 2 minutes, until my efforts for a better view disturbed them, and they scurried apart and disappeared. I watched the spot for about 15 minutes and sighted one animal at a time about five times moving about the margins of the litter, or around the basal parts of the stems, which were laying flat on the ground. I concluded the watching when I saw one individual at the margin of the litter suddenly dash across about 1m of bare ground then slowly disappear into a dense mass of *Tetragonia* . The litter was not deep and there were four apparent burrow openings under the bush (3 old storm petrel, one *Egernia bos*).

Copulation

At 1010 am on November 14, 1994, two adult *C.lancelini* were seen in a copulatory position in a pit when the cover was lifted. After slow removal of the cover I saw the two animals lined up longitudinally, with the male's tail (both sexed later) under the female's and vents very close (my view was limited to dorsal). I watched them in that position for about 2 minutes and noted that the male's respiratory rate was about double that of the female. The male broke the apparent union and I could see the extended intromittent bits still exposed. He remained stationary for about 5 seconds, took one slow step, them moved very quickly and the hemipenes disappeared.

Gravid Females

The classification of 'female: gravid' (FG) only referred to females which were in the later stages of egg production when handled. In both seasons the majority of FG were caught during November. During 1994 only 44 of the 78 females (56%) handled were classified as FG, but in November 1995, 69 of the 73 (95%) females handled were FG. The relative abundance of gravid females during the two seasons may be associated with the abundance of smaller adult females, which were absent from the 1995 adult female population.

These data suggest most larger adult females (SVL > 78 mm) breed each year. Records for six females caught during both the 1994 and 1995 breeding seasons showed they were gravid both years.

Field observations showed that the captured female population became increasingly gravid (as indicated by both numbers of gravid vs slender and the extent of distention of the body) up until about November 20. By the first week in December the female population appeared to have become much less gravid. From mid-December on few gravid females were caught, the latest recording being for a late January capture.

Reliable information regarding the age of adult females at reproductive maturity is sparse because of low recriutment during the study period. It seems probable that during a run of good seasons young female *C.lancelini* might be able to breed during their second summer season (nearly two years old). Records for breeding females from September-December 1994 indicate that some females probably don't breed until their third summer season. Young females which suffer repeated significant tail loss, or a run of dry seasons seem unlikely to achieve sufficient body weight for breeding (probably about 7g) until their third summer season.

Incubation Sites

Little direct information is available about incubation sites. However, the distribution of captures of females and FG was so far from random, it suggested that the quality of incubation sites was a resource of major concern to individual breeding females, and hence, of major importance to the Island population. The concentration of captures of FG in only a few pits suggested that high-quality incubation sites were relatively rare (7-12% of pit sites), and were shared by many females (45% of all females were caught in 6 pits in 1995).

G70 and G0-120 included the major incubation areas located within trapping grids. G70 included the only steep, protected, north-northeast slope on any of the limestone areas. On the eastern side of the Island, a steep sand slope (2-5 m high, slope up to 1:1 or 45°) separates the higher gentle slopes of the large central dune and the white sand swale. The slope was formed during absence of the eastern swale, by erosion of supporting sand, and its aspect varies from east at the low southern end, to NE at the higher, steeper, northern end. G0-G120 were towards the northern end of the swale, at the base of the slope.

Captures of FG on G70 show that the part of the grid associated with pits 75, 77 & 78 was favored by FG compared with the rest of the area. The triangle of habitat enclosed by these three pits has a combination of aspect, slope and protection (from S-SW wind) factors not represented elsewhere within the limestone areas. It has, for the limestone areas, a good cover of low perennial shrub (*Atriplex cineria*) with deep litter below. Its area is about 40-50 square metres, and represents less than 1% of the total limestone area.

On G0-G120, pits at the base of the slope caught most FG. The favoured incubation area is probably the lower part of the steep slope, but may include a narrow strip of the adjacent white sand. The area has excellent protection from S-SW winds. The NE aspect facilitates incident solar radiation early in the day. The slope has little perennial vegetation, is riddled with seabird burrows and grows dense stands of winter grasses, which decline to small dense patches of dry grass cover by mid-December. On the slope, the burrowing activity of seabirds after mid-winter ensures a patchy nature to the grass, since excavated sand streams down the slope, laying the grass flat below a few inches of sand.

Two incubation areas (G0 & G70) were represented within the eleven main grids used between January and early March (post hatching) in both seasons. G70 and G0 caught 85% of all juveniles caught in Jan-mid-March 1994. During the 1995 season 41% of juveniles came from these two areas. This pattern suggests that during some seasons the best incubation sites are the only ones to produce a catchable number of hatchlings, but in other seasons, many other incubation sites may produce hatchlings. It seems probable that the 1994 season was a poor season for either egg-production or incubation, and 1995 was much better, with reproductive success much higher.

Diet

Thirteen pellets from adult *C.lancelini* were collected (7 in 1994, 6 in 1995). Nine pellets contained earwig remnants. All earwig fragments identified were of *G.michaelseni* . In 1994, 4 other species of terrestrial insect were identified from pellets: two true bugs (Heteroptera), and one tenebrioid and one chrysomelid beetle. In 1995, the only two other deitary items identified in pellets were a cockroach egg-case, and a lizard egg membrane. The lizard egg membrane was collapsed and embedded with earwig remnants in a fibrous material which was identified as earwig gut contents.

The insect remnants found in pellets were associated parts of one or more individual prey items (all insects). The four species of small insects were often almost whole, and individuals were estimated to each weigh up to about 5-20% of the weight of an Island earwig. Earwigs from pellets were usually well masticated, but reassambly of the different segments usually revealed the abdominal segments of one earwig in a pellet (only one pellet contained two earwigs). Thus the minimum number of individuals which could account for all remnants provides a small sample of items representing individual predatory actions. In 1994, the seven pellets contained a minimum of 28 individual insects: 5 earwigs and 23 individuals of four other species (all of which were much smaller than an Island earwig). The six pellets collected in 1995 contained a minimum of five earwigs, and the only non-dermapteran insect represented was the cockroach eggcase. Thirty percent of the 33 occurrences of predation of insects available from the 13 pellets were of earwigs.

The earwig's gut digests dead organic matter, often from fibrous remnants of dead plant material: this partially digested material may be a nutritionally significant dietary component, especially if earwig guts are blessed with appropriate microflora.

Relative Capture Rates and Habitat Characteristics

The *C.lancelini* capture rates for the thirteen grids used in late September-December 1994 were very high on a few grids, moderate on most grids, and very low on a few grids. The most simplistic interpretation of such a pattern is that the variation in capture rates reflects variation in relative abundance of *C.lancelini* due to variation in habitat quality. The concept of habitat quality as used here refers to the full suite of environmental parameters which have the potential to limit local abundance, and does not exclude any type of potentially limiting factors. If habitat quality is so defined, then the assumption that the capture rate is proportional to habitat quality can be used to rank habitat quality for sampled sites.

Investigation of habitat characteristics associated with high, moderate or low quality sites facilitates identification of major habitat characteristics which have the potential to limit local abundance. For most homothermic animals the major factors are the availability of food and shelter. Reptiles depend to variable degrees on using environmental heat to elevate their body temperature. Reproduction of reptile populations which incubate the eggs in substrate may be highly dependant on habitat characteristics associated with thermal parameters, and perhaps also soil moisture levels.

The major habitat characteristics considered below are: substrate, vegetation (including weeds), topography (which influences local thermal parameters) and food abundance, as indicated by capture rates of the major dietary species.

Substrate

C.lancelini was caught on each of the three main substrate types of shallow soil on limestone, the deep sands of the large central dune and the white sand of the eastern swale. All three habitat types had grids with moderate to high capture rates, and relatively low capture rates were also recorded for all three habitat types.

Vegetation

Vegetation on each grid is described in Appendix I, and a ratio of the abundance of weeds and perennials was derived from the descriptions (further explanation of derived variables: see Appendix I). Table 14 lists the derived variates which indicate the overall relative, abundances of weeds and perennial plants on each grid.

Grid	Weeds	Perenials	1994 CL capture rate
GO	15	80	11.4
G10	25	90	2.2
G20	60	55	11.1
G30	70	35	0.5
G40	20	105	1.7
G50	15	75	3.4
G60	70	30	0.4
G70	70	30	16.2
G90	95	5	1.3
G100	30	65	6.4
G110	75	25	6.0
G120	15	85	15.3
G130	40	60	7.2

Table 14. The relative abundance of weeds and perennial plants and 1994 capture rate for adult *C.lancelini* for each grid.

The most extensive cover of winter weeds occurred on the shallow soil over limestone of southern and northern extremities of the Island. Five grids were in this habitat type. G90 had the most extensive weed cover and the lowest abundance of perennials, but it's C.lancelini capture rate was higher than G30 or G60 which both had less weeds and more perennials. G60 and G70 had equivelent occurrence of both plant types, but G70 had the highest, and G60, the lowest, capture rate.

These data indicate that, if variation in vegetation does influence *C.lancelini* habitat quality, that influence is small compared to other aspects of habitat variation.

Topography

The trend for grids with high *C.lancelini* capture rates to have protected N-NE aspects and those with low capture rates to have more exposed or less NE aspect became apparent early in the study. Converting these general trends to sets of quantitative, normally distributed habitat variables was well beyond the resources available for this project.

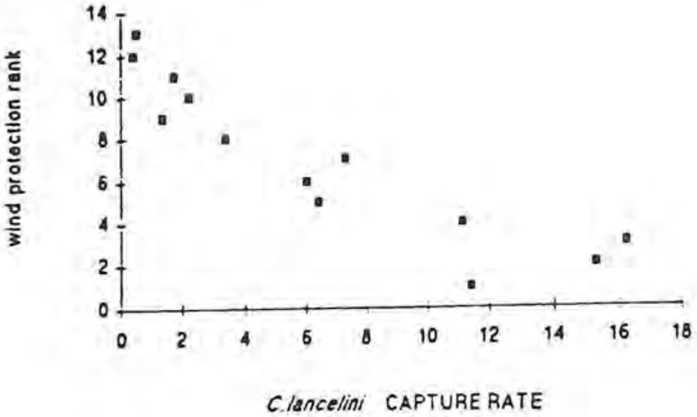
The predominant slope for each grid was estimated along both NS and EW axes. A wind protection rank was assigned to each grid (see Methods: rank 1 for the most protected grid). Table 15 shows the values thus derived for each grid. The estimated slopes for G0 did not represent the adjacent slopes well, since the NE facing rise was just beyond the grid margin.

Table 15. Topographic features of each grid. The grid with the best protection from the prevailing S-SW winds was assigned the lowest rank. The slope on grids was described by an estimate of the vertical distance between the highest and lowest points on each axis (NS and EW). The orientation of the slope is indicated as N for grids which sloped down to the N, and S for grids which sloped down towards the south.

	wind protection rank	slope faces	elevation (m)	slope faces	elevation (m)
G0	1	-	0	W	1.5
G10	10	N	0.2	E	0.6
G20	4	N	0.4	E	1.2
G30	13	S	0.3	E	0.1
G40	11	S	1.7	W	0.1
G50	8	S	0.4	E	0.1
G60	12	S	0.8	E	0.2
G70	3	N	1.8	E	1.8
G90	9	S	0.2	W	0.2
G100	5	-	0	W	2.7
G110	6	S	1.5	E	0.6
G120	2	N	2.6	E	0.9
G130	7	N	0.3	E	2.5

Figure 5 shows a plot of (1994) *C.lancelini* capture rates and wind ranks for each grid.

Figure 5. Plots of each grid's *C.lancelini* capture rate (for late September-December 1994) and wind ranks (from Table 15).



The windiest grids had the lowest *C.lancelini* capture rates, and the highest *C.lancelini* capture rates were on the most protected grids.

On Lancelin Island the two major components of microclimatic variation are linked: only slopes facing N to E have both high wind protection and good incident solar radiation. Western slopes don't receive incident solar radiation until afternoon (which is when the S-SW winds blow most reliably), and thus substrate temperatures fall during darkness, and are not 'topped up' for about 15 hours. East or north facing slopes only cool from dusk until dawn or early morning , and so would provide less extreme diurnal variation in substrate temperatures. The available data can not be used to identify these potentially separate effects.

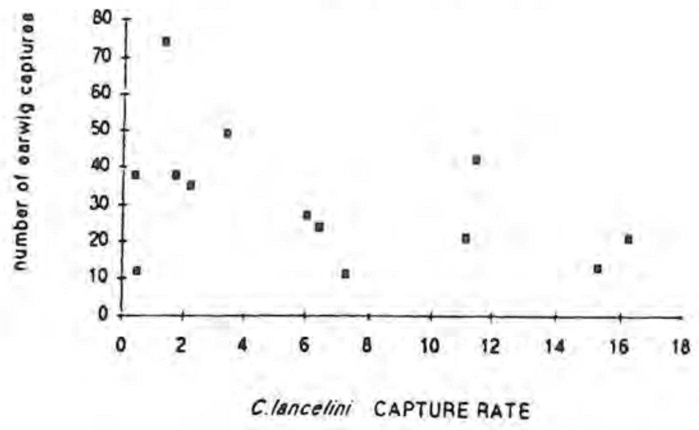
Food abundance

Adult earwigs (*G.michaelseni*) were caught in all months, and were the most common terrestrial insect caught (accounting for ca 70% of insects caught or 40% of all invertebrates caught). Data used in this section results from grid capture rates for adult *C.lancelini* (as given in Appendix 2 tables) and the number of earwigs recorded for each grid on seven trips between late September to December in 1994 and 1995. Thirteen grids were used in 1994 and 9 of these were also used in 1995.

The abundance of earwigs in an area is likely to be proportional to the amount/quality of habitat minus any predation factor. Earwigs eat decaying organic matter, prefer a humid and dark microclimate and tend their eggs diligently during incubation (i.e. localised; Rentz and Kevan, 1991). On Lancelin Island they may weigh up to 0.1 g.

Figure 6 shows that the two highest earwig capture rates were recorded on grids with few *C.lancelini* captures, and that grids with the highest *C.lancelini* capture rates had low earwig counts. These data prompt the suggestion that *C.lancelini* predation has the potential to limit earwig abundance.

Figure 6. Plots of each grid's earwig count and *C.lancelini* capture rate, as recorded for thirteen grids in late September-December 1994.



Relative capture rates of *C.lancelini* and earwigs for nine grids used in both years (Table 16) show that in 1994 there was, on average, 6 earwigs caught for each *C.lancelini* . The average (1995) *C.lancelini* capture rate (for the 9 grids) was about 25% lower than in 1994, and 27 earwigs were caught for each *C.lancelini* . The grids with the largest increases of earwigs between 1994 and 1995 tended to have the largest declines in *C.lancelini* capture rate, with the exception of G70.

Table 16. Capture rates for *C.lancelini* in late September-December 1994 and 1995 and the numbers of earwigs caught on all 7 sample days in each year for grids used in both seasons.

	1994			1995		
	C.lancelini cap. rate	earwig count	earwigs per CL capture	*C.lancelini* cap. rate	earwig count	earwigs per CL capture
G0	11.4	42	4	13.5	47	3
G10	2.2	35	16	3.7	36	10
G20	11.1	21	2	7.4	29	4
G40	1.7	38	22	3.3	56	17
G70	16.2	21	1	14.6	71	5
G100	6.4	24	4	2	41	21
G110	6	27	5	0.5	84	168
G120	15.3	13	1	10.1	38	4
G130	7.2	11	2	3.2	46	14
sum		232			448	
average			6			27

The above trends provide substantial circumstantial evidence which suggests that predation by *C.lancelini* may influence local earwig abundance. If this is so, then, by implication, earwig abundance has the potential to limit habitat quality for *C.lancelini* .

Population numbers

The Capture Data

The *C.lancelini* capture records do not conform to the requirements of data suitable for reliable population estimates. Immigration was substantial, trappability low, and there was a possibility that gravid females may have been caught more frequently than any other group. The extent to which the capture records were influenced by females moving to incubation areas is unknown. Incubation areas can not be defined on the ground. The area which each trap actually sampled is unknown: each trap's capture rate is a point estimate of the usage of a small area by nearby *C.lancelini* .

Despite these unknown factors, a coarse estimate of the population size is possible. The data on captures during September-December 1995 (Table 6) provides the best available data on the numbers of animals using the area sampled by nine grids.

By the end of December 1995, 132 marked CL (103 females and 29 males) were known to have used the sample area defined by the nine main grids. In the early part of the season, about half of all captures were of individuals marked during the previous season, but the recapture rate fell to a stable average of 33-34% for each of the season's last three trips (Trips 42, 43, 44).

If the 132 marked individuals represented one-third of the adults which used the sample area during the breeding season, then the total would be estimated as 396 (of which about 300 were females). This is the *minimum* number of individuals which are required to account for all captures. Some individuals marked during the previous season would have been alive in the area, but not caught, so the 132 marked individuals is also the minimum number of marked individuals.

Population densities

Using an assumption that each pit sampled a square area of 100 m^2, and each grid, 900 m^2, suggests that a density estimate for the sampled area would average about 400 *C.lancelini* /ha.

The average grid capture rate for the 1995 season was 6 *C.lancelini* /100TD. Capture rates on low-usage grids (assumed low density) averaged about 3 *C.lancelini* /100TD, and about 13 *C.lancelini* /100 TD on high usage grids (assumed high density) grids. These data suggest that density probably varied from about 200-800 *C.lancelini* /ha. Low density grids used in 1994 only (e.g. G30, G60) would have averaged far fewer than 200/ha in the small sampled area.

Population estimate

The area sampled by the grids was not a random representation of Island habitats because of the relative over-representation of the steepest and best protected N-NE slopes, and the consequently high female capture rates. If 15% of the Island (about 1 ha) carried 800/ha, and the rest carried 200/ha, the total 1995 population would have been about 3000 adults.

4.3 Lancelin Trapping

Trapping on seven grids on the Lancelin foreshore between mid-November and late December yielded 122 captures of *C. fallens*, and no *C.lancelini* captures during 882 TD. On the Island, a total of 91 *C.lancelini* were trapped during the same period.

The Lancelin Island average *C.lancelini* capture rate for the same period was 8 *C.lancelini* / 100 TD (based on captures on all main grids). Excluding the 3 grids with high female capture rates (G0, G70 & G120) gave an average capture rate of 3.4 *C.lancelini* / 100 TD. The Lancelin Island grid with the lowest *C.lancelini* capture rate during this period (G110) caught only 1 (subadult) *C.lancelini* , at a rate of 0.8 *C.lancelini* / 100 TD.

Supposing that one *C.lancelini* (rather than none) had been caught during the Lancelin foreshore trapping provides an estimated maximum capture rate of 0.1 *C.lancelini* / 100 TD. Using this supposition, *C.lancelini* capture rates on Lancelin Island were (at least) 8-80 times greater than mainland grids.

Trapping was undertaken during the period of the seasonal peak of capture rates on Lancelin Island. The possibility that low-density mainland populations may have had males more abundant than females (and therefore be more trappable early in the season) did not dawn on me until the season was gone.

5. DISCUSSION

The diet of *C.lancelini* consisted almost entirely of food which was dependant on the humid and dark conditions which characterise the deeper layers of litter accumulations. The pattern of topographic variation in capture rates suggests a third characteristic of areas where *C.lancelini* forages: warm, humid and dark. These inferences about habitat usage by *C.lancelini* are consistent with the rarity of surface sightings and the low trappability of the species. The species morphology is also consistent with *C.lancelini* being a specialised litter forager: it has, when compared to other Island skinks, a slender head, small eyes, shortish limbs and a long body for its weight.

Trapping in the two adult breeding seasons used different subsets of grids, and males were almost twice as hard to catch in the second season. It seemed to be a perplexing coincidence that despite these seasonal differences, the average *C.lancelini* capture rates for each season were almost identical (6 and 6.1 *C.lancelini* / 100 TD). These results seem to challenge the assumption that the capture rate is directly proportional to density.

The average *C.lancelini* capture rate was derived from a set of 80-120 points (different trapsites), indicating that derived averages could be expected to be statistically sound. Hence, the equivelent average capture rates indicate that although adult population numbers declined, the same level of usage was maintained by the fewer adults in 1995. One important implication of this observation is that, during 1994-5, the density of the adult *C.lancelini* population on Lancelin Island was influenced primarily by within-species limits to local density (i.e. a major habitat factor limiting local *C.lancelini* abundance was the number of *C.lancelini* already present). Another implication is that the capture rate of 6.1 *C.lancelini* / 100 TD is this trapping technique's indicator of 'full' for an hypothetical 'average habitat' on Lancelin Island in the 1994-5 seasons.

Adults of the skinks on Lancelin Island had different patterns of seasonal activity, and of body shape and size which suggested that the species respective foraging niches were distinct. The adult activity seasons were well spaced, except for the overlap of the two spring-early summer, *Ctenotus* . The two *Ctenotus* differed morphologically, with *C.lancelini* being relatively longer than *C.fallens* (CL: 6.2 mm of

SVL for each gram of body weight; CF: 4.2 mm of SVL / g body weight), and having shorter hindlimbs (CL: 34% of SVL; CF: 38% of SVL). *C.fallens* is morphologically most suited to cover longer distances over the surface, while *C.lancelini* is best suited to pushing through deeper litter. The high trappability of *C.fallens* may indicate that the trap array sampled *C.fallens* 's surface foraging niche more effectively than it sampled *C.lancelini* 's litter foraging one.

The potential for significant competitive interaction between species appeared greatest for juveniles of the three egg-laying species, which emerged from late December and foraged into autumn and for *M.lineoocellata* , winter. The body shape of young differs from adults (legs and body relatively long for the body weight), so foraging niches of young may be expected to differ somewhat from adults. All young would be taking similar sized prey, save for *C.fallens* having the longest jaw and largest gape. It is notable that the smallest young (*M.lineoocellata*) emerged earliest in the season, followed by the middle-sized young (*C.lancelini*), and the largest young (*C.fallens*) were the latest to emerge. As with other components of this study, the potential for investigating the possible impact of competition for prey between juvenile lizards was limited by the low abundances of young *C.lancelini* .

The extent of survival enjoyed by a yearly *C.lancelini* cohort as eggs, hatchlings or subadults was the primary factor with the potential to limit adult abundance during this study. The survivorship of young predetermined the potential maximum number of adults in each yearly cohort, and so influenced the size and structure of the adult population in subsequent years. A summer-autumn period with sufficiently hot and dry conditions, as in 1994, reduced surivivorship past the first winter to an undetectable level. Young monitored in 1995 lost weight from hatching up to the first rain of the season: the survivors started gaining weight within days of the rain. Hot dry conditions were associated with lower levels of invertebrate captures, and young in such a season would suffer both starvation and dehydration. So, although climate was the trigger for the low recruitment, food abundance was probably the critical factor.

The capture records showed clearly that individual *C.lancelini* preferred areas with the best available thermal conditions, so long as social interactions with neighbours were tolerable, and the food resource was adequately accessible. Large breeding females had the best level of access to the warmest and most protected areas, and the smaller males tended to be excluded from these areas. As a consequence of individual *C.lancelini* growing and seeking better access to higher quality habitat, the local abundance and identity of individuals in lower quality habitat varied substantially between seasons. The population characteristics (e.g. adult sex ratios, capture rates) for areas with high capture rates were much more stable between years.

The major environmental parameter which affected *C.lancelini* habitat quality was local microclimate. Favored microclimates were characterised by incident solar radiation available early in the day, and for a maximum part of the day, and associated protection from cool S-SW winds. In areas with unfavorable microclimate for *C.lancelini* , earwigs were abundant, suggesting that for individual *C.lancelini* , good thermal habitat characteristics were of more value than an extensive food supply.

C.lancelini were never seen basking in sunlight. Given their cryptic lifestyle, and the nature of the substrates on Lancelin Island, basking is probably undertaken in the top 1 cm of patches of loose sand, where temperatures would be much higher than in shaded litter.

Thermal parameters also seemed to be the major factor affecting the females' choice of incubation sites. Some young were encountered in all areas of the Island which were trapped, suggesting that successful hatching was not restricted to the popular incubation areas during 'better' seasons. In 'worse' seasons, almost all young came from the most popular incubation areas. The factors affecting incubation site quality will presumably be defined by soil conditions of humidity and the daily cycle of temperature fluctuation. Both factors could be influenced by variations in climate, topography, and the mosaic and extent of vegetation. The extent and rate of change to habitat parameters such as vegetative cover and aspect of sandy slopes suggests that incubation areas may be 'mobile', with the best patches in one year being 'degraded' by say, an adjacent bush growing to the east, and casting a longer morning shadow each year.

The diet of adult *C.lancelini* appeared to be influenced by seasonal fluctuation in food abundance. About 70 % of the faecal pellets inspected contained remnants of at least one earwig (*G.michaelseni*). Earwigs were rare in the 1994 season, and the *C.lancelini* ate more of the other terrestrial litter insects (true bugs and beetles) than in 1995.

The pattern in the relative capture rates of *C.lancelini* and earwigs suggested an intimate predator-prey relationship between the populations. Results showed evidence of an inverse relationship between *C.lancelini* and earwig capture rates which suggested that in areas with favored *C.lancelini* microclimate, earwig density was limited by the impact of predation by *C.lancelini* . The highest local densities of earwigs were observed in pits immediately adjacent to deeper accumulations of dead vegetation.

Food abundance appeared to be the underlying critical factor leading to the exclusion of males from small areas with high densities of females. Social factors appeared to limit the local density of males, and this may infer complex social behaviour and imply the existence of some sort of territory. A territory model based on a small mobile personal space would probably be most appropriate. However, a more simple model could adequately explain the pattern in the data: smaller *C.lancelini* may tend to avoid larger *C.lancelini* .

The future viability of *C.lancelini* on Lancelin Island will depend on the extent, rate and nature of change to *C.lancelini* habitat quality which may occur with climatic fluctuations, and increasing weed and visitor abundance. The weak link in *C.lancelini* 's tenure on Lancelin Island appears to lie in the small popular incubation areas. The conservation value of the rare, high-quality incubation areas on Lancelin Island is highlighted by considering that a few patches of weedy sand and knee-high scrub amounting to, say, 1000 square meters may have been responsible for the bulk of the species reproduction over the last few decades.

Further detailed studies of habitat usage by breeding females on Lancelin Island are required to permit identification of high-quality incubation areas, and to identify habitat characteristics which define incubation site quality.

During the study the impact of climatic variation was clearly illustrated as having the potential to exterminate a yearly cohort of young. Given the uncertainty of the future climate due to 'greenhouse' and 'holes in the ozone layer', and the subsequent possibility of more frequent or longer El Nino fluctuations, it may be that climate change is the major threat to the species.

The ratios of females to males observed for adult *C.lancelini* during this study appear inconsistent with *Ctenotus* sex ratios observed by James (1991), who reported that in six central Australian *Ctenotus* , males were caught more frequently than females. Only one of the species James studied had females caught more frequently than males, and it was also the only species to produce young in most years. All of the species with males caught more often than females did not produce young each season.

The equivalent recapture rates for female and male *C.lancelini* provides confirmation that, in this study, relative capture rates for males and females can provide a useful approximation of the population structure. On Lancelin Island, female *C.lancelini* accounted for almost 80% of adult captures during the 1995 season. The male population accessed only about 20% of the Island's *C.lancelini* habitat resource (which was measured as 6.1 *C.lancelini* /100 TD in 1994-5). The tendency for male abundance to fall in tough seasons provides a degree of population 'insurance' against natural climatic extremes.

Ford (1969) found that the density of lizards of several SW species was much higher for some island populations than for known mainland populations of the same taxon. He concluded that in island reptile faunas, each taxon enjoyed a wider foraging niche than available in mainland habitats which had more diverse faunas, and hence more competitive constraints to the extent of the foraging niche. Mainland trapping showed that the abundance of breeding females in the only known mainland population was undetectably low. The high abundance of females on Lancelin Island probably reflects the species potential to fully exploit small areas of the highest habitat quality.

6. SPECIES MANAGEMENT

Most rare fauna management programmes in Australia are undertaken because a species is known to have declined. There is no evidence that *C.lancelini* has suffered range decline since the arrival of Europeans.

This study's results show that large variations in temporal and annual abundance can be expected for the high-density population on Lancelin Island. If Browne-Cooper and Maryan's (1992) results did reflect true decline in local abundance within the limestone area which they searched, then such decline was probably part of a 'natural' cycle of fluctuating abundance.

Fluctuations in population size associated with adverse seasons may, or may not, conceal an underlying, longer-term trend of species decline on Lancelin Island. Further, fluctuations in temporal and annual abundance of adults (due to climate during the first few months of a hatchling's life) impose a major constraint on any research which needs to interpret measured changes in capture rates of *C.lancelini* .

6.1 Management aims

The primary aim of future species management must be to ensure that the species conservation status does not decline from its current level. The secondary aim is to ensure that, should extinction of the Lancelin Island population occur, it would not be species extinction. Improvement of the species conservation status becomes, by necessity, a tertiary aim. The following discussion relates primarily to a period of two or three decades.

The primary and secondary aims necessitate that no unobserved decline affects the Lancelin Island population in the short term (5-15 years). The secondary aim necessitates existence of a breeding colony of *C.lancelini* which is independent of Lancelin Island.

If management endorses and successfully achieves the aims, the probability of the species long-term persistence is maximised. If management fails to achieve the primary or secondary aims the species conservation status will be severely limited by the possibility that decline and extinction may occur unobserved.

The main criterion used herein to evaluate the relative merits of proposed management strategies is the degree to which any strategy would deliver a predictable and valuable increase to the species conservation status.

6.2 Management strategies

If the people responsible for species management commit to, and achieve, the primary goal of ensuring the Lancelin Island population remains viable, then other management strategies will, in effect, function as an 'insurance policy' for the species persistence. Other species management options considered by Burbidge (1993) were translocation, captive breeding and the discovery of another population. Captive breeding is the only one of the three options which can be relied upon to satisfy the secondary and tertiary aims over the short term (5 years).

Translocation

Three main problems are associated with translocation. Monitoring the survival of released animals would be a very difficult (perhaps impossible) task. The successful establishment of a new *C.lancelini* population may take 10-15 years to verify, and may result in decline or local extinction in the original fauna. Confirmation of the absence of *C.lancelini* prior to release of Lancelin Island stock would require extensive trapping, and may still fail to detect a resident, low-density occurrence.

Searches for Other Populations

Structured searching for other *C.lancelini* populations will only provide an increase in the species conservation status if viable populations are discovered. If structured searching detected no viable populations, much funding would have been consumed, but no improvement in species conservation status would have been purchased.

Most available information about the occurrence of reptiles on SW Islands derives from single day hand searches: had Lancelin Island been without the rocky limestone areas where *C.lancelini* was easily detected by rock-turning it is highly probable the species would still remain unknown. The extent of unsuccessful trapping at Lancelin Point shows that low-density, presumably viable, populations can be very hard to detect, and suggests that mainland densities could be expected to be much lower than island densities. Ford (1963) showed that the largest SW islands had the highest reptile diversity, and that islands with the most seal or cormorant damage to vegetation tended to have fewer reptiles than those with little seal or cormorant damage.

These considerations suggest that the most efficient approach to locating further populations lies with seeking to discover populations which are likely to be high density, and these are most likely to occur on islands.

The best prospect for improving the species conservation by discovering further *C.lancelini* populations lies with trapping with covered pits on coastal islands during appropriate seasons. Larger islands which lack turnable rocks have the best potential to foster undiscovered *C.lancelini* populations. If *C.lancelini* turns up on another island or two, then difficult mainland surveys should not be required for the maintenance of the species conservation status.

The low recruitment of Lancelin Island *C.lancelini* due to adverse climate in 1993 and 1994 is likely to have affected density throughout the species range. Given the low trappability of *C.lancelini* , searches for other populations should be undertaken when populations have had several seasons of climate which was good for recruitment.

Captive Breeding

Captive breeding is underway and yielding encouraging results, and a recipe which describes all conditions for successful captive breeding provides valuable insurance against extinction in both the short and long-term. Assuming the current Zoo programme is continued to its completion, a reliable recipe for captive breeding should be available in 3-5 years.

The nature and quality of the documentation describing the techniques currently being developed is of considerable conservation value. If a detailed recipe for successful captive breeding is produced by the present Zoo programme, and that recipe (and it's documentation) is good enough to be used by an independent body to successfully establish a *C.lancelini* breeding programme, then the recipe draft which exists at the end of the two projects will have been both tried and tested. Such reliable documentation facilitates an option for the maintenance of the species in captivity to end.

A major and critical aspect of developing the captive breeding recipe relates to possible future outcomes for *C.lancelini* . If the captive breeding recipe is to be of value beyond (say) 15 years, then it must be developed under the assumption that if someone wants to initiate a captive breeding programme, it will be because the species has declined in abundance. Breeding females may be rare, and hence it may be critical that the highest success rates for available eggs can be achieved swiftly.

The captive breeding females at Perth Zoo provide a valuable opportunity to collect rigorous quantitative data about the substrate conditions favoured by females for egg deposition. Results would be valuable for management of such areas on Lancelin Island.

6.3 Management of the Lancelin Island Population

Local abundance of *C.lancelini* in the Lancelin Island population was primarily limited by microclimate quality and food abundance and the effects of climatic variation on these parameters. During the period of the field study, adverse climatic conditions played the major role in limiting population size, by reducing potential recruitment to the breeding population to undetectable levels. Incubation site quantity/quality was the only structural habitat parameter identified as having the potential to limit population size. These parameters are consistent with a predatory skink population functioning in an ecologically viable way.

Although Lancelin Island is a nature reserve, the habitat of *C.lancelini* can not be considered secure in the long-term. It is probable that the numbers of people visiting the Island for recreation will increase substantially as a number of proposed coastal developments are completed over the next 5-15 years. The Island's shrubby perennial vegetation may be declining as winter weeds expand. Even in areas with extensive winter grasses, pockets of woody debris remain on the soil or rock surface, and these may be contributing (substantially?) to the maintenance of invertebrate populations. The spread of weeds and the increasing visitor load are both considered to have the potential to impact on the viability of *C.lancelini* on Lancelin Island. Both factors may adversely affect the Island population in as little as 10 years.

The restricted, high-quality incubation areas on sandy slopes are particularly vulnerable to human disturbance. On sandy slopes people's feet wreak havoc on the slope and aspect, and crush seabird burrows. No data is available which could be used to reliably identify or accurately delineate incubation areas, making such areas impossible to protect effectively. Useful recommendations regarding protection of these small important areas requires further field data to allow identification of their characteristics, extent and abundance, and to assess the extent of annual mobility of areas with the best thermal parameters for incubation.

Should further research be undertaken by trapping incubation areas it would be prudent to use small staff (with low body-weight), since these people's footsteps will lead to a much lower rate of crushing seabird burrows. The steep sandy eastern slopes were avoided in this study, since it was obvious that walking on the slope would lead to major destabilisation.

Habitat manipulation on Lancelin Island

Habitat treatments have been proposed (Burbidge 1993) which would attempt to improve *C.lancelini* habitat quality on Lancelin Island. If undertaken in the context of a management experiment, the effects on the lizard population would need to be monitored using trapping. The extent of annual and topographic variation in *C.lancelini* local abundance would make interpretation of apparent population changes a nightmare, unless the design used large numbers of both control and treatment areas. Treating or trapping in random areas may damage unrecognised but potentially important incubation areas.

Burbidge (1993) also suggested spraying weeds with Fusilade. Rolfe (1993) attempted the task (using a somewhat dilute mix). Spraying on Lancelin Island to limit weed abundance has a very low probability of success in killing even one season's growth of rye-grass. The weeds need to be sprayed at an appropriate age (probably about July) on a day with little wind, and little precipitation/condensation which dilutes the poison before it is absorbed by the foliage. During June and July such weather is extremely rare and unpredictable. By August the grasses have started to flower.

Fusilade is apparently only effective against grasses. At present the grasses inhibit the growth of the broadleaf weed, Ice plant (*M.crystallinum*) which can be expected to occupy any ground where the grasses have been killed. (Ice plant thrives from May-December, but the rye grass dies off in October).

6.4 Management recommendations

The recommendations are listed in order of diminishing priority.

1. **Initiate long-term monitoring on Lancelin Island** to:
   (i) monitor the annual abundance *C.lancelini*
   (ii) document the annual extent of winter weeds

2. **Continue the captive breeding programme at** Perth Zoo
   (i) until a breeding recipe has been successfully tested by another body
   (ii) to document physical aspects of females' preferred egg-laying conditions

3. **Initiate field studies of breeding sites** to determine:
   (i) the extent and location of 'popular' incubation areas
   (ii) the habitat factors which affect incubation site quality

4. **Undertake surveys of selected islands** during seasons of high abundance on Lancelin Island

Endorsement of Rec **1** and **2** will lead to a significant improvement of the species conservation status within 5-8 years. Results collected as a consequence of undertaking Rec **1**, **2** and **3** will vastly improve the efficiency and reliability of data collected in the course of Rec **4**, so Rec **4** should be deferred.

Field-work associated with Rec **1** and **3** could be conducted as a single project.

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APPENDIX I

Grid Descriptions

Brief descriptions of the 13 trapping grids used on Lancelin Island are given below. The locations of the grids is shown in Figure 1 in the main text. Vegetation descriptions make reference only to common plants (here 'common' is defined as covering at least 5% of the grid area) which were apparent during November 1994. Estimates of the extent of cover of any component refer to an estimate of the total area of each grid covered by a particular component: in some areas more than one species covered the same area (e.g. *Tetragonia decumbens* climbing over *Spinifex longifolia*, or winter grasses emerging from *Rhagodia baccata* thickets). The relative abundance of weeds and perennial plants on each grid was summarised by the **W:P** ratio, defined as the sum of cover of weed species (Winter grasses + Ice plant): the sum of cover of perennial plant species.

G0 (includes GA): Substrate of white (beach) sand in a narrow swale on the eastern foredune; protected from S-SW winds by the large central dune, which rose steeply and immediately to the WSW of the grid. **Cover**: Winter grasses: 15%; bare sand: 5%; *Myroporum insulare*: 10%; *Nitraria billardieri*: 10%; *Olearia axillaris*: 5%; *Rhagodia baccata*: 10%; *Scaevola crassifolia*: 15%; *Spinifex longifolius*: 15%; *Tetragonia decumbens*: 10%; *Zygophyllum fruticulosum*: 5%. **W:P ratio: 15:80**

G10: On a gentle white sand slope on the eastern foredune; no protection from S winds, but some protection from SW winds by the large central dune, which rose about 15 m to the W the grid. **Cover**: Winter grasses: 25%; bare sand: 10%; *Atriplex isatidea*: 5%: *M. insulare*: 15%; *N.billardieri*: 5%; *O.axillaris*: 10 %; *R.baccata*: 5%; *S.crassifolia*: 15%; *S.longifolius*: 15%; *T. decumbens*: 15%; *Z.fruticulosum*: 10%. **W:P ratio: 25:90**

G20: On sand of eastern lower slopes of central dune. Moderate protection from SW winds by large central dune. **Cover**: Winter grasses: 60%; bare sand: 5%; *O.axillaris*: 10%; *R.baccata*: 30%; *T. decumbens*: 10%; *Z.fruticulosum*: 5%. **W:P ratio: 60:55**

G30: Shallow soil over limestone on the small SE limestone peninsula: the central pit was at the apex of a slight rise, and the surface fell away from the central pit in all directions (slopes < 0.5 m). Exposed to the S-SW winds.
Cover: Winter grasses: 45%; *Atriplex cineria*: 15%; *Frankenia pauciflora* : 15%; *Mesembryanthemum crystallinum*: 25%; *R.baccata*: 5%. **W:P ratio: 70:35**

G40: On the southern lower slopes of the large central dune. Exposed to the S-SW winds.
Cover: Winter grasses: 20%; *A.cineria* : 30%; *F.pauciflora* : 15%; *N.billardieri* : 5%; *R.baccata*: 20%; *Z.fruticulosum*: 35%.
W:P ratio: 20:105

G50: On the sothern lower slope of the large central dune. Exposed to the S winds, but with some protection from SW winds.
Cover: Winter grasses: 15%; *A.cineria* : 35%; *R.baccata*: 20%; *S.crassifolia* : 5%; *Z.fruticulosum* : 15%. **W:P ratio: 15:75**

G60: Shallow soil on limestone with a gentle SSW slope. Exposed to the S-SW winds.
Cover: Winter grasses: 65%; *A.cineria* : 10%; *F.pauciflora* : 15%; *M.crystallinum* : 5%; *R.baccata*: 5%. **W:P ratio: 70:30**

G70: Shallow soil on limestone slope with a NW-NE aspect and slopes of 1m (to the NW) and 2m (to the NE). Protected from SW winds by the rise on which G60 was located.
Cover: Winter grasses: 65%; *A.cineria* : 25%; *M.crystallinum* : 5%; *R.baccata*: 5%. **W:P ratio: 70:30**

G90: Shallow soil on limesone flat with very slight SW slope. Slight protection from S winds was provided by the rise on which G60 was located.
Cover: Winter grasses: 90%; *M.crystallinum* : 5%; *R.baccata*: 5%.
W:P ratio: 95:5

G100: On western slope of central dune. Some protection from S winds provided by the western margins of the large central dune.
Cover: Winter grasses: 30%; *N.billardieri* : 40%; *O.axillaris*: 5%; *Z.fruticulosum*: 20%.**W:P ratio: 30:65**

G110: Shallow soil over limestone on southern slope. Moderate protection from SW winds provided by the large central dune.
Cover: Winter grasses: 75%; *A.cineria* : 10%; *F.pauciflora* : 5%; *R.baccata* : 10%. **W:P ratio: 75:25**

G120: In a narrow swale on white sand of the eastern foredune (adjacent to G0); with a NNE aspect, protected from S-SW winds by the large central dune, which rose steeply and immediately to the W of the grid.
Cover: Winter grasses: 15%; bare sand: 10%; *O.axillaris* : 5%; *R.baccata* : 5%; *S.crassifolia* : 50%; *S.longifolius* : 20%; *T.decumbens* : 5%. **W:P ratio: 15:85**

G130: On the southern apex of the central dune, the grid extends down the eastern slope. Moderate protection (for most of the grid) from SW winds by large central dune.
Cover: Winter grasses: 40%; bare sand: 5%; *R.baccata* : 15%; *Z.fruticulosum* : 45%. **W:P ratio: 40:60**

APPENDIX II

Big Tables

Seven tables summarising captures of *C.lancelini* per grid and trip for: adult females and males in 1994 (p 65-66); adult females and males in 1995 (p 67-68), subadults in 1995 (p 69) and recent hatchlings in 1994 (p 70) and 1995 (p71).

1994

captures of female *C.lancelini*

effort per grid	grid	month trip	S T20	O T21	O T22	O T23	N T24	N T25	D T26	D T27	no of females per grid	capture rate (grid)	% of all females per grid
210	G0		1	2			6	10	1		20	9.5	16
131	GA			1			4	8	1	1	15	11.5	12
225	G10							3			3	1.3	2
234	G20		1	2		3		1	2		9	3.8	7
221	G30						1				1	0.5	1
234	G40							1			1	0.4	1
234	G50		1					2			3	1.3	2
234	G60										0	0.0	0
234	G70		3	3	1		4	15	1		27	11.5	21
234	G90						1				1	0.4	1
218	G100		1			1	1	1			4	1.8	3
234	G110		3	1		1		2	1		8	3.4	6
236	G120			2		1	6	14	4	1	28	11.9	22
234	G130		1	1	1	1		4			8	3.4	6
Totals 3112			11	12	2	7	23	61	10	2	128		
effort per trip			424	545	242	357	413	531	357	244			
trip capture rate (caps/100TD)			2.6	2.2	0.8	2	5.6	12	2.8	0.8			
% of all females per trip			9	9	2	5	18	48	8	2			

1994's average trip capture rate: 3.53 adult female CL/100 TD

1994

captures of male *C.lancelini*

effort			number of adult males caught									no of	capture	% of all
per		month	S	O	O	O	N	N	D	D		males	rate	males
grid	grid	trip	T20	T21	T22	T23	T24	T25	T26	T27		per grid	(grid)	per grid
210	G0		1			2		1				4	1.9	5
131	GA		1							1		2	1.5	3
225	G10					1	1					2	0.9	3
234	G20		2	3	1	2	3	3	1	2		17	7.3	21
221	G30											0	0.0	
234	G40						2	1				3	1.3	4
234	G50			1		2	1	1				5	2.1	6
234	G60						1					1	0.4	1
234	G70			1	1	6	1	2				11	4.7	14
234	G90						2					2	0.9	3
218	G100					4	1	2	3			10	4.6	13
234	G110		3				2		1			6	2.6	8
236	G120		1	2			2	2	1			8	3.4	10
234	G130		1	2		1	3	2				9	3.8	11
Totals 3112			9	9	2	18	19	14	6	3		80		
effort per trip			424	545	242	357	413	531	357	244				
trip capture rate (caps/100TD)			2.1	1.7	0.8	5	4.6	2.6	1.7	1.2		average	2.47	
% of all males per trip			11	11	3	23	24	18	8	4				

1994's average trip capture rate: 2.47 adult male CL/100 TD

1995

captures of female *C.lancelini*

effort per grid	grid		number of adult females caught									no of females per grid	capture rate (grid)	% of all females per grid
		month	S	O	O	O	N	N	N	D	D			
		trip	T36	T37	T38	T39	T40	T41	T42	T43	T44			
216	G0			1	1	1	3	7	6	4	3	26	12.0	23
121	GA					1	1	7	7			16	13.2	14
214	G10					1		1	3			5	2.3	4
217	G20			1		1	2	2	1	1	2	10	4.6	9
0	G30													
208	G40			1	1				1		1	4	1.9	4
0	G50													
0	G60													
212	G70		2		1		1	4	16	4		28	13.2	25
157	G90			1								1	0.6	1
202	G100					1					1	2	1.0	2
211	G110											0		
217	G120		1		1		1	9	1	1	3	17	7.8	15
217	G130			2			1	1	1			5	2.3	4
Totals 2190			3	6	4	5	9	31	36	10	10	114		
effort per trip			189	202	224	221	188	319	319	316	211			
trip capture rate (caps/100TD)			1.6	3	1.8	2.3	4.8	9.7	11	3.2	4.7			
% of all females per trip			3	5	4	4	8	27	32	9	9			

1995's average trip capture rate: 4.70 adult female CL/100 TD

1995

captures of male *C.lancelini*

effort per grid	grid	month	S	O	O	O	N	N	N	D	D	no of males	capture rate	% of all males
		trip	T36	T37	T38	T39	T40	T41	T42	T43	T44	per grid	(grid)	per grid
216	G0			1	2							3	1.4	10
121	GA										1	1	0.8	3
214	G10					2				1		3	1.4	10
217	G20		1		1	2			2			6	2.8	19
0	G30													
208	G40			1	1				1			3	1.4	10
0	G50													
0	G60													
212	G70					1				2		3	1.4	10
157	G90					2						2	1.3	6
202	G100		1			1						2	1.0	6
211	G110					1						1	0.5	3
217	G120		1					2	2			5	2.3	16
217	G130									1	1	2	0.9	6
Totals 2190			3	2	4	9	0	2	5	4	2	31		
effort per trip			189	202	224	221	188	319	319	316	211			
trip capture rate (caps/100TD)			1.6	1	1.8	4.1	0	0.6	1.6	1.3	0.9			
% of all males per trip			10	6	13	29	0	6	16	13	6			

1995's average trip capture rate: 1.43 adult male CL/100 TD

1995

captures of subadult *C.lancelini*

effort			number of subadults caught									no of	capture	% of all
per		month	S	O	O	O	N	N	N	D	D	subadults	rate	subadults
grid	grid	trip	T36	T37	T38	T39	T40	T41	T42	T43	T44	per grid	(grid)	per grid
216	G0											0		
121	GA					1						1	0.8	6
214	G10											0		
217	G20		1	3	1		1				1	7	3.2	41
0	G30													
208	G40											0		
0	G50													
0	G60													
212	G70			1								1	0.5	6
157	G90					1						1	0.6	6
202	G100		1					1		1		3	1.5	18
211	G110					1			1			2		12
217	G120								1			1	0.5	6
217	G130					1						1	0.5	6
Totals 2190			2	4	1	4	1	1	2	1	1	17		
effort per trip			189	202	224	221	188	319	319	316	211			
trip capture rate (caps/100TD)			1.1	2	0.4	1.8	0.5	0.3	0.6	0.3	0.5			
% of all subadults per trip			12	24	6	24	6	6	12	6	6			

1995's average trip capture rate: 0.84 subadult CL/100 TD

1994

captures of juvenile *C.lancelini*

effort			number of juveniles caught										no of	capture	% of all
per		month	J	J	F	F	F	M	M	A	A	A	juv's	rate	juv's
grid	grid	trip	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	per grid	(grid)	per grid
216	G0		1	4		1				1		1	8	3.7	40
73	GA									2	1		3	4.1	15
220	G10												0		
230	G20						1						1	0.4	5
230	G30												0		
200	G40												0		
222	G50					1				1			2	0.9	25
230	G60												0		
187	G70					3	2						5	2.7	
222	G90												0		
200	G100												0		
220	G110												0		
108	G120												0		
108	G130							1					1	0.9	5
Totals 2661			1	4	0	5	3	1	0	4	1	1	20		
effort per trip			336	178	218	218	274	236	354	360	244	244			
trip capture rate (caps/100TD)			0.3	2.2	0	2.3	1.1	0.4	0	1.1	0.4	0.4			
% of all juveniles per trip			5	20		25	15	5		20	5	5			

1994's average trip capture rate: 0.83 juvenile CL/100 TD

1995

captures of juvenile *C.lancelini*

effort			number of juveniles caught								no of	capture	% of all
per		month	J	J	F	F	M	M	A	A	juv's	rate	juv's
grid	grid	trip	T28	T29	T30	T31	T32	T33	T34	T35	per grid	(grid)	per grid
133	G0			3		1	4				8	6.0	14
87	GA		1	5						2	8	9.2	14
154	G10			5					1		6	3.9	10
150	G20				1		1				2	1.3	3
134	G30										0		
150	G40								2	2	4	2.7	7
150	G50			1	2	1					4	2.7	7
150	G60				3						3	2.0	5
150	G70			3		1	1		1	1	7	4.7	12
150	G90				2		1				3	2.0	5
117	G100						1				1	0.9	2
150	G110						1			1	2	1.3	3
148	G120		4	3			1				8	5.4	14
150	G130				1		1				2	1.3	3
Totals 1974			5	20	9	3	11	0	4	6	58		
effort per trip			336	178	218	218	274	236	354	360			
trip capture rate (caps/100TD)			1.5	11.2	4.1	1.4	4		1.1	1.7			
% of all juveniles per trip			9	34	16	5	19		7	10			

1995's average trip capture rate: 3.13 juvenile CL/100 TD