RE-INTRODUCTION OF STICK-NEST RATS TO REEVESBY ISLAND SOUTH AUSTRALIA

WWF World Wide Fund For Nature

by
Lynn Pedler
and
Peter B. Copley

Biological Conservation Branch
South Australian Department of Environment and Land Management

RE-INTRODUCTION OF STICK-NEST RATS TO REEVESBY ISLAND SOUTH AUSTRALIA

WWF Australia Project No. 175

by
Lynn Pedler
and
Peter B. Copley

WWF World Wide Fund
For Nature

February 1993
Biological Conservation Branch
South Australian Department of Environment and Land Management

Cover: First release Reevesby Island female *Leporillus* (eartag no. 1901) fitted with radio-transmitter collar, recaptured on 21 June 1991 with three relatively new young attached (Photo: Lynn Pedler)

ISBN No. 0 7308 2693 7
Cartography and Design by Public Communications Branch
Department of Environment and Land Management
FIS 14169

CONTENTS

FIGURES **Page No.**

FIGURES **Page No.**

TABLES **Page No.**

EXECUTIVE SUMMARY

Four releases of captive bred *Leporillus conditor* totalling 101 individuals were made on Reevesby Island between September 1990 and September 1991. Survival, dispersal and breeding were monitored during this period using radio transmitters, modified pitfall trapping, Elliott trapping and spotlighting. Released *Leporillus* had a high survival rate and most had gained weight within six weeks of release.

Initial dispersal was random with six animals remaining within 50 m of their release site and movements up to 1 km found within three days. After six weeks, half (8) of the first release *Leporillus* remained within 200 m of their release site and others had moved up to 3.5 km away. Females were subsequently found using core home ranges of < 1 ha. Males used larger home ranges and movements of up to 800 m overnight were observed. Up to five litters per female were found within nine months. Mean litter size was 1.56. At least 57 young were found, of an estimated 100 produced in this period. Data on family groups and dispersal of juveniles were obtained. Limited predation by owls was detected.

A strong founding population estimated to exceed 200 individuals was established by the end of 1991.

CONCLUSIONS AND RECOMMENDATIONS

This program has emphasised that the success of any re-introduction program depends upon:

- a sound understanding of the biology and ecological requirements of the species being re-introduced
- careful selection of appropriate re-introduction release sites with regard for the types, abundance and availability of food and shelter, and ensuring that levels of predation (especially while the new population establishes) and competition, are minimal
- careful husbandry of animals while in captivity (especially during transportation activities)
- detailed monitoring of a representative sample of the released population to ensure that the program proceeds satisfactorily and that if problems arise they can be detected quickly and rectified; (radio-telemetry techniques were far superior to any other monitoring methods in this case).

Further specific points were also highlighted by this program. Most may appear to be basic common-sense; however it is worth recommending their consideration in all similar programs.

1. Stresses to any species being re-introduced should be kept to an absolute minimum prior to release into a new environment.

    - All pre-release handling of animals such as weighing, eartagging, examination of general body condition and reproductive state, fitting of radio-transmitters and any blood or tissue sampling for genetic studies should be done at least 1-2 days before capture for transportation and release at their re-introduction site. That is, *none* of these things other than examination of general body condition and checking that transmitter collars are still fitting comfortably (and perhaps weighing), should be done at the point of release.

2. Transportation and transit times should be as brief as possible to further minimise stress to the animals.

3. Animals should preferably be transported in familiar surroundings. Standard nest-boxes used at Monarto were used for transporting *Leporillus* to the island. They were then left at the point of release for several weeks as familiar objects (with familiar scents) for the rats to use.

4. An essential insurance policy for the time, money and other resources invested in any re-introduction program *is a workable monitoring program.* Radio-tracking was found be far superior to the use of spotlights, Elliott traps and pitfall traps, in relocating released animals *on a regular and reliable* basis, and maximised information obtained on relative movements, reproductive success and changes in body condition.

5. The one death probably attributable to a fitted radio-collar may have been avoided by removal or securing of an excess length of brass collar. These excess lengths often include one or more small adjustment bolt holes which may get caught on vegetation. By cutting them from the collar (or covering them by crimping the end over) after fitting, this potential danger may be avoided.

6. *Leporillus* caught in Elliott traps may quickly become soaked in their own copious urine and, if left in a cold, breezy situation may become hypothermic. This may be minimised by placing suitable quantities of absorbent material at the rear of the trap and by placing the trap in a sheltered position.

7. Pitfall traps may capture more than one animal per night, often of more than one species. Smaller, relatively defenceless species like stick-nest rats and storm-petrels may be severely injured or even killed if they are captured in the same trap as an angry, stomping Little Penguin, a large Cape Barren Goose chick (or two) or a venomous tiger snake or death adder. To date, only one small tiger snake has been captured in a pitfall trap, the lack of connecting pitfall fence-lines probably keeping such captures to a minimum. However, penguin and goose captures occur regularly, (although the latter are seasonal, in winter), and pose a significant risk to the rats. This has been minimised by placing short sections of PVC downpipe horizontally in the base of each pit. Rats, storm-petrels and small lizards can then shelter in these anti-tromping devices, away from kicking penguin or goose feet. They can also shelter from the rain.

8. Several *Leporillus* have suffered substantial weight losses due to several successive captures and/or lengthy exclusions from feeding. This effect may be minimised by placing large slices of carrot or other suitable food items in each pit trap. Carrot is recommended as it does not attract ants.

9. Incidental trapping of storm-petrels and Cape Barren geese could be avoided by trapping in March, April, May and August and September, although this is not a critical consideration.

10. Finally, female stick-nest rats frequently drag their young about firmly attached to their nipples. Caution should therefore be exercised when attempting to capture any adult *Leporillus* to ensure that no young are dislodged or injured.

INTRODUCTION

The Stick-nest Rat *Leporillus conditor* (Fig. 1) formerly occurred widely across southern Australia (Fig. 2) but is now believed to be extinct on the mainland. Only one population of about 1000 individuals remains (Copley 1988) on East Franklin and West Franklin Islands off the far west coast of South Australia (Fig. 3).

In 1985 a captive breeding program was established at the SA NPWS fauna facilities at Monarto east of Adelaide with animals from the Franklin Islands (Copley 1988). The purpose of this captive breeding program is to provide captive bred *Leporillus* to establish further populations, preferably in areas the species formerly occupied and which are free of introduced predators.

In South Australia two islands were selected as preferred initial release sites; Reevesby Island in the Sir Joseph Banks Group Conservation Park and St Peter Island in Nuyts Archipelago Conservation Park (Fig. 3). This report details the release and initial establishment of a new population of *Leporillus* on Reevesby Island . A second population, not described here, has been established on Salutation Island, Shark Bay, Western Australia also from the Monarto captive breeding program. A subsequent release of additional captive-bred animals is scheduled for St Peter Island in 1993.

Reasons for the choice of Reevesby Island as a release site are outlined by Copley (1988). These include evidence of the former presence of *Leporillus conditor* (skeletal remains - see Fig. 4), the extent of suitable habitat and potential absence of introduced predators. The latter was achieved in March 1990 when the last feral cat was caught (Pedler 1991; see Fig. 5).

Reevesby Island, (Fig. 6) which covers an area of 344 ha, is the largest island of the Sir Joseph Banks Group Conservation Park, situated northeast of Port Lincoln and about 20 km south east of Tumby Bay in Spencer Gulf, South Australia.

Figure 1 A greater stick-nest rat, *Leporillus conditor*, West Franklin

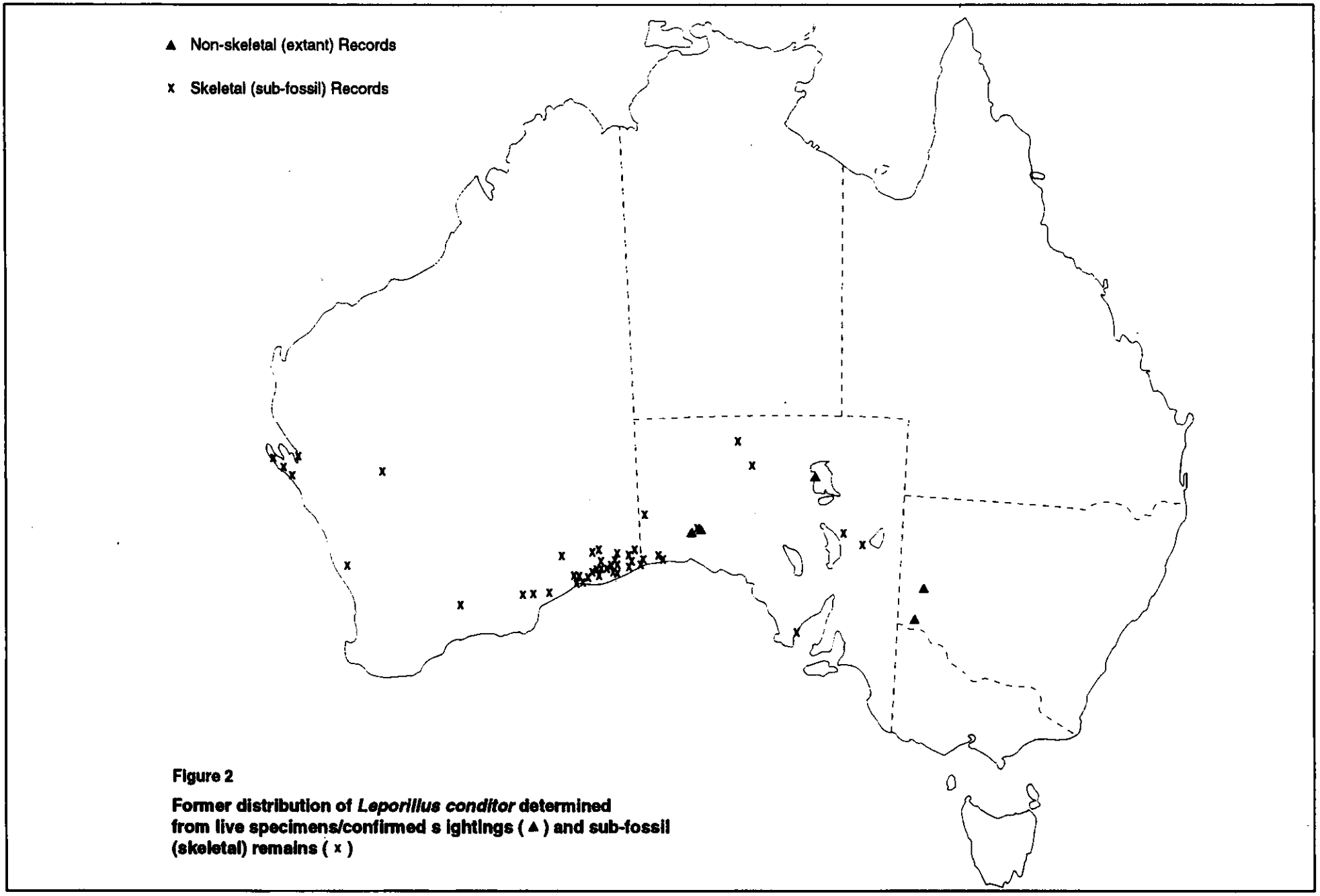


Figure 2

Former distribution of *Leporillus conditor* determined from live specimens/confirmed s ightings (▲) and sub-fossil (skeletal) remains (x)

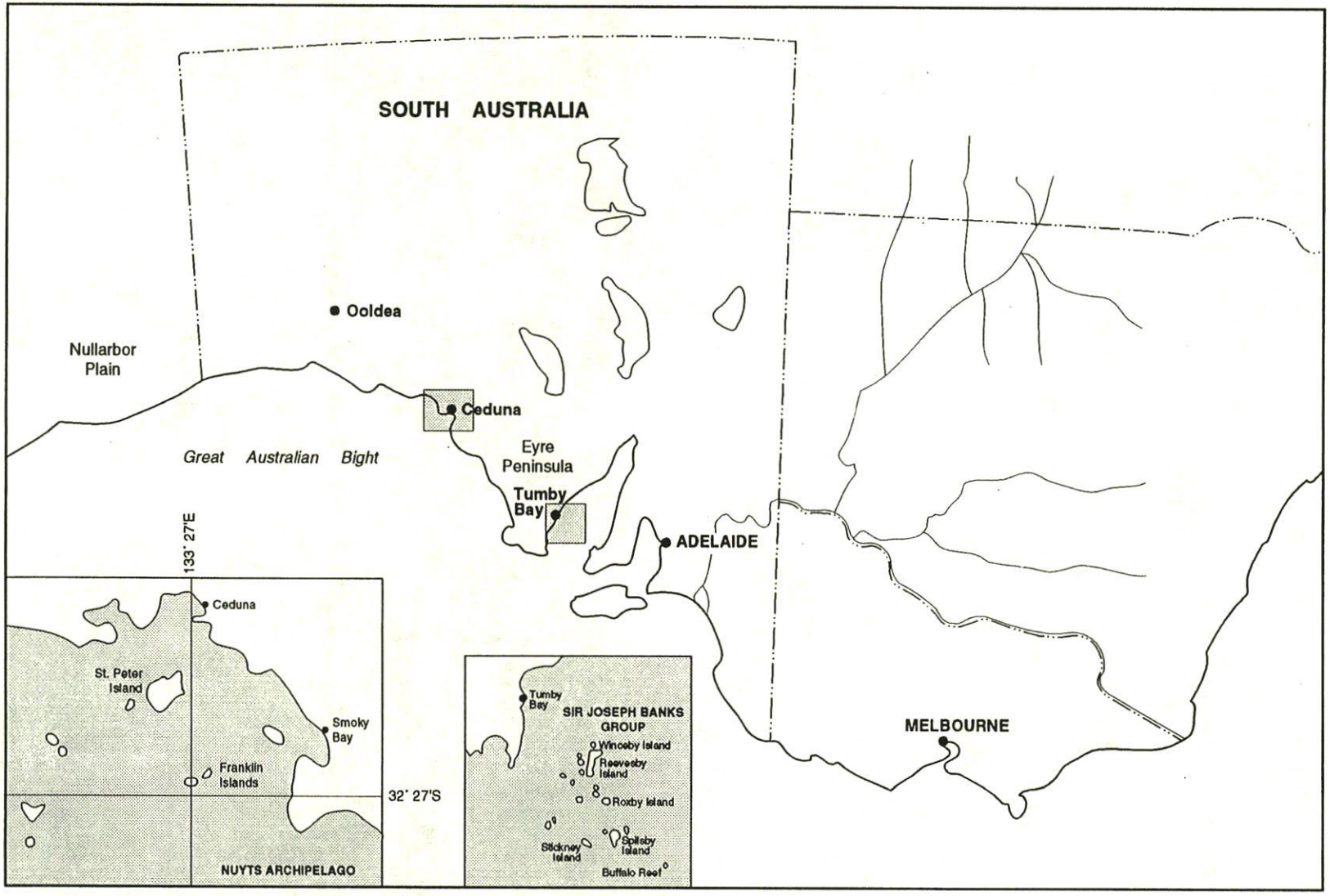


Figure 3

Location of the last remaining populations of *Leporillus conditor*, East and West Franklin Islands, Nuyts Archipelago Conservation Park, and the reintroduced population, Reevesby Island, Sir Joseph Banks Group Conservation Park South Australia

Topography comprises sandplain, low white dunes and sandy soil over a limestone and granite base which outcrops as rocky headlands. These are joined by sandy beaches (Fig. 5).

Habitats have been altered by clearing for agriculture and grazing of livestock (mainly sheep) which continued from 1838 until about 1974. The main habitats are *Myoporum insulare* and *Olearia axillaris* tall open shrublands in the dune and sandplain areas (Fig. 7), grassland of mostly introduced pasture species in areas formerly cleared for agriculture and low chenopod shrubland of mainly *Atriplex paludosa* on some headlands (Fig. 5). African Boxthorn *Lycium ferocissimum* has spread through most of the cleared land and shrublands since farming ceased and these large shrubs now form a conspicuous part of the island vegetation (as well as difficult sites for capturing *Leporillus*).

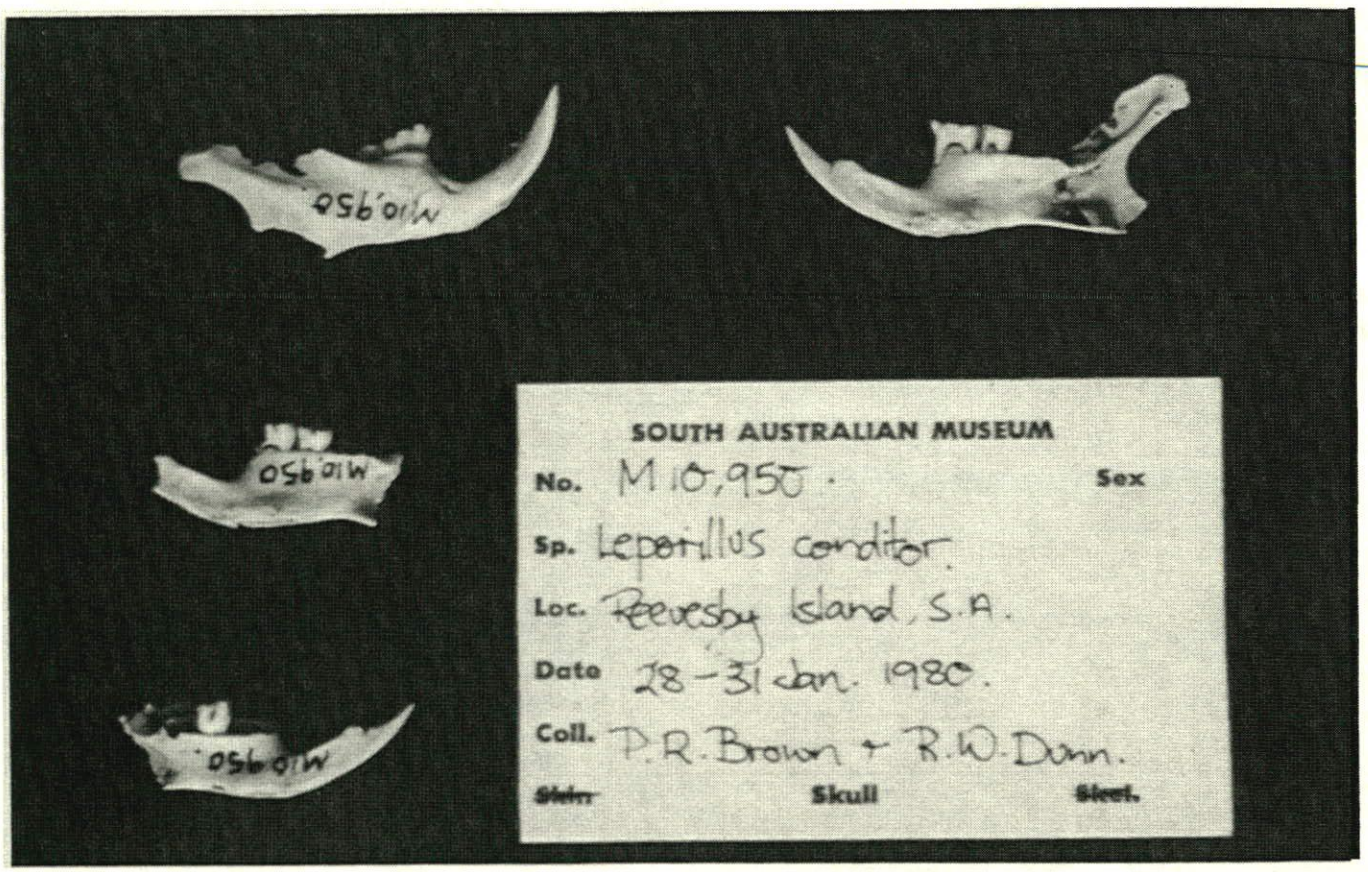


Figure 4 Sub-fossil jaw remains of *Leporillus conditor* from a sand blow-out on Reevesby Isalnd

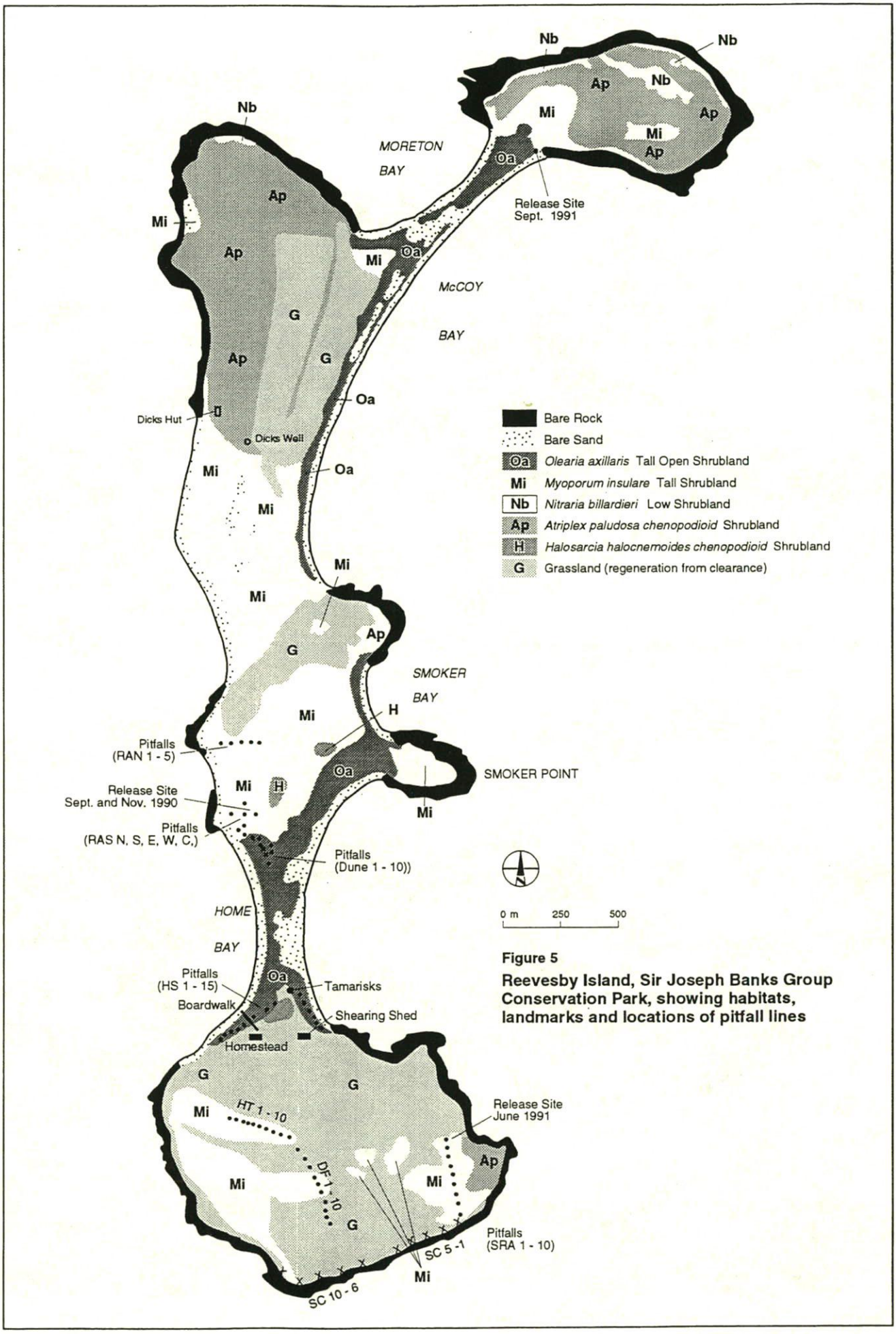


Figure 5

Reevesby Island, Sir Joseph Banks Group Conservation Park, showing habitats, landmarks and locations of pitfall lines

Figure 6 The first ferral cat, *Felis catus*, captured in the feral cat eradication program, Reevesby Island, February 1985

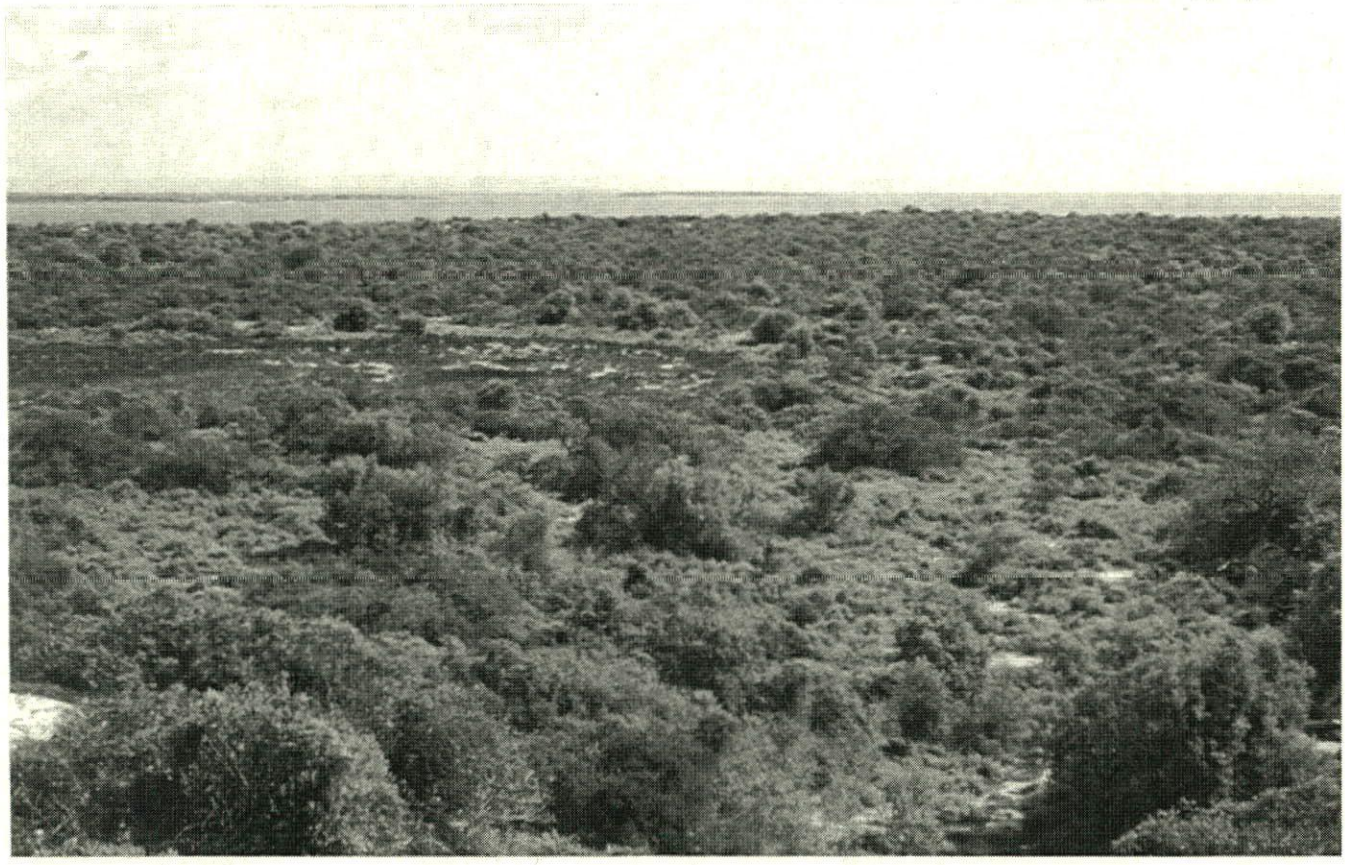


Figure 7 View of the central portion of Reevesby Island looking WNW over the initial *Leporillus* release area

METHODS

Eight visits of 2 - 7 days duration and totalling 42 days were made to Reevesby Island between September 1990 and September 1991 to release and monitor stick-nest rats. Access to Reevesby Island was by boat from Tumby Bay, taking approximately one hour. Landing was usually on Home Bay beach. All work on the island was carried out on foot, with the assistance of between one and five volunteers and SANPWS personnel.

Stick-nest rats for release were bred in 3 m x 7.5 m aviaries at the SANPWS Monarto Fauna Complex, from a nucleus of animals captured on the Franklin Islands (Copley 1988). A total of 101 *Leporillus conditor* (51 M, 50 F) were released in four batches on Reevesby Island during this study.

Most *Leporillus* released were young adults between three and eight months old. Age, weight and sex of *Leporillus* released are summarised in Table 1.

TABLE 1. Summary of age, weight and sex of captive-bred *Leporillus conditor* released on Reevesby Island, 1990 - 91.

1st Release 24/9/91	:	12 aged 3 - 8 months, 200 280 g
weighed at release	:	1 (M) 8 weeks, 210g incl. collar
(with 10g collars)	:	3 (F) 12 - 22 months, 350 - 385 g
TOTAL	:	16 (7 M, 9 F)
2nd Release 5/11/90	:	15 aged 3 - 8 months, 170 - 300 g
weighed 30/10/90	:	1 (F) 16 months, 305 g
(without collars)		
TOTAL	:	16 (6 M, 10 F)
3rd Release 18/6/91	:	29 aged 3 - 6 months
(not weighed	:	7 aged 9 - 18 months
at release)	:	6 aged 21 - 27 months
TOTAL	:	42 (22 M, 20 F)
4th Release 9/9/91	:	27 aged 10 weeks - 5 months
weighed 6/9/91		
(no collars)	:	105 - 300 g
TOTAL	:	27 (16 M, 11 F)
OVERALL TOTAL	:	101 (51 M, 50 F)

TRANSPORT AND RELEASE

Rats were transported, in separate compartments, or with two or three siblings together, in wooden nest boxes of the type used in the captive breeding colony. Each compartment was supplied with sufficient food. The time from being placed into boxes until release was from 12 to 24 hours, with transport by vehicle and/or air and boat. Releases were made in the evening at three sites.

The first release site, in *Myoporum* shrubland (Figs. 5 & 7), was chosen for its near central location on the island and its plentiful supply of dense cover and appropriate foodplants (eg. Figs 8 & 9) for stick-nest rats (as assessed by Copley 1988), while access and open areas between shrubs meant that observations and recapture would be possible. The later releases were in areas of habitat similar to that already used by stick-nest rats on Reevesby Island, but in areas which few or no rats had occupied, 1.5 - 3 km from the first release site.

The first two releases of *Leporillus* (September 1990 and November 1990) from which most subsequent observations came, were near the middle of the island. The June 1991 release was near the southern end of the island and the September 1991 release was at the northeastern end (see Fig. 5).

TRANSMITTERS USED

Radio transmitter collars (type TXLLDL, weight 10 g, estimated battery life 6 weeks) were supplied by BioTelemetry Tracking (Australia). Actual battery life was found to be greater than the estimated life as signals had not deteriorated noticeably by 12 weeks and two transmitters were found after 16 and 20 weeks, the latter however only giving a weak signal audible from about 30 m. The usual range at which signals were detected was about 100 - 150 m on flat, shrubby terrain and up to 500 m from high points on the island.

All of the first 16 rats released (9F, 7M) were fitted with radio transmitter collars for the first six weeks from release and three (F) of these wore collars for the whole study period (50 weeks). Transmitter collars were removed from nine of the 'first release' rats when recaptured in November, six weeks after release. (Three of these (2 M, 1 F) were later caught and again fitted with collars while others wore collars for various periods). Six (1 M, 5 F) of the 16 rats released in November were fitted with collars and three (F) of these wore collars until the end of the study (45 weeks). Two others (1 M, 1 F) wore collars until June 1991 (33 weeks). From February and April several un-collared captive-bred males and several island-born rats were also fitted with collars. Similarly, five of the 43 *Leporillus* released in June were fitted with collars. Thus, at any given time throughout the study between 11 and 16 rats were fitted with transmitters.

Table 2 shows the periods for which individual *Leporillus* were fitted with transmitter collars.

RECAPTURE METHODS

For recapture of collared rats, to recover transmitters for battery replacement and to determine condition and breeding status of these rats, a 65 cm wide plastic sheet was erected with wire pegs as a temporary fence around the bushes (often large dense boxthorns) in which the rat or its radio signal was located (Fig. 10). The occupant(s) were then flushed into the open against the fence where they could be caught. Flushing of *Leporillus* usually required vigorous shaking of their cover or, more frequently when this did not succeed, one catcher tunnelled underneath or into the dense mass of vegetation while assistants waited for rats to emerge. Usually no attempts were made to capture collared rats, except for retrieval and/or replacement of collars. However, if possible, collared rats were located daily, or at least once during each visit to the island, noting their location and whether they, and/or associated rats or progeny, were seen or detected moving within dense cover.

Figure 8 ***Tetragonia implexicoma*, an important food and shelter plant for *Leporillus***

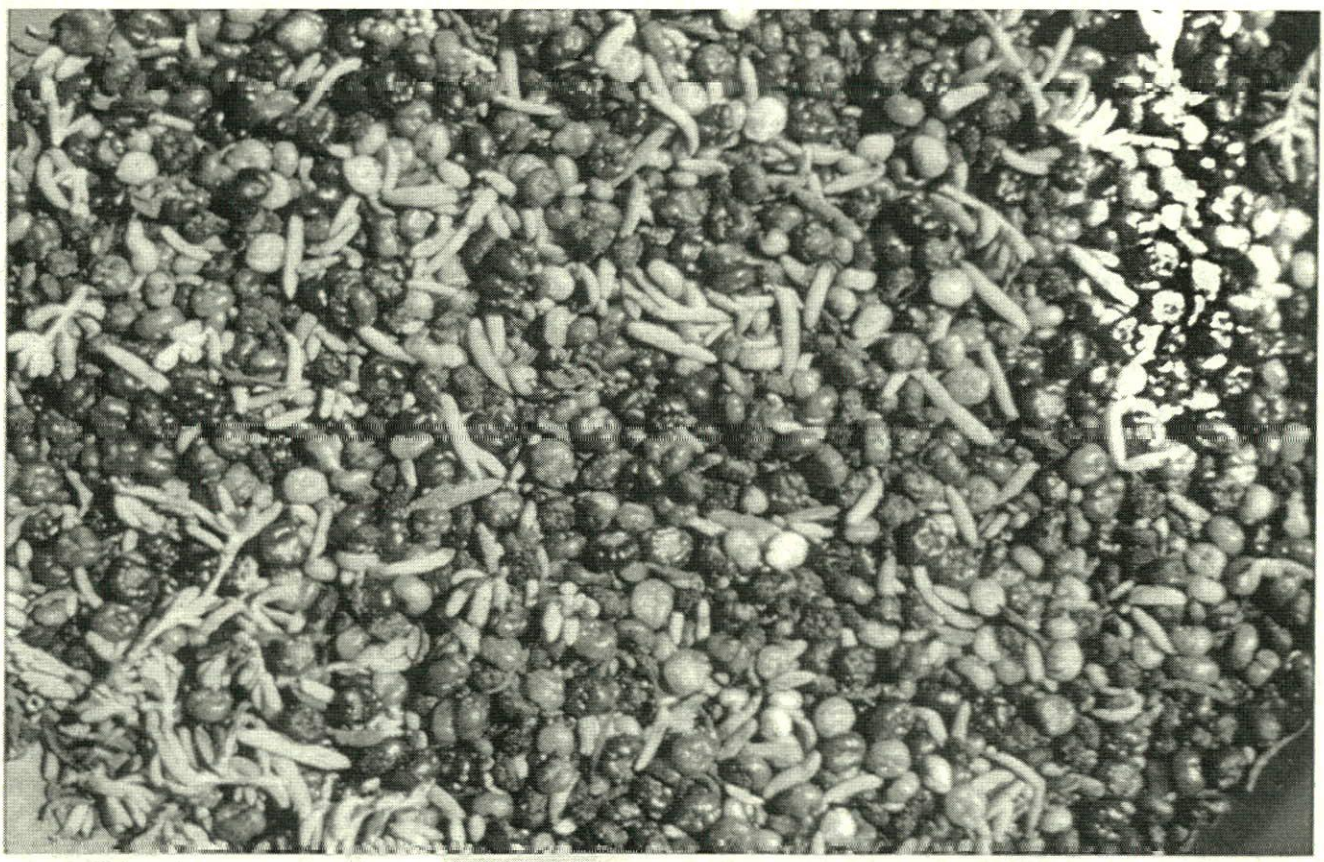


Figure 9 **Fruits of ruby saltbush, *Enchylaena tomentosa*, an important summer and autumn source of food and water for *Leporillus* (approx, x1)**

Figure 10 Portable plastic fence erected around a dense (mostly dead) vine of ***Muehlenbeckia adpressa*** to assist with recapture of a radio-collared ***Leporillus***

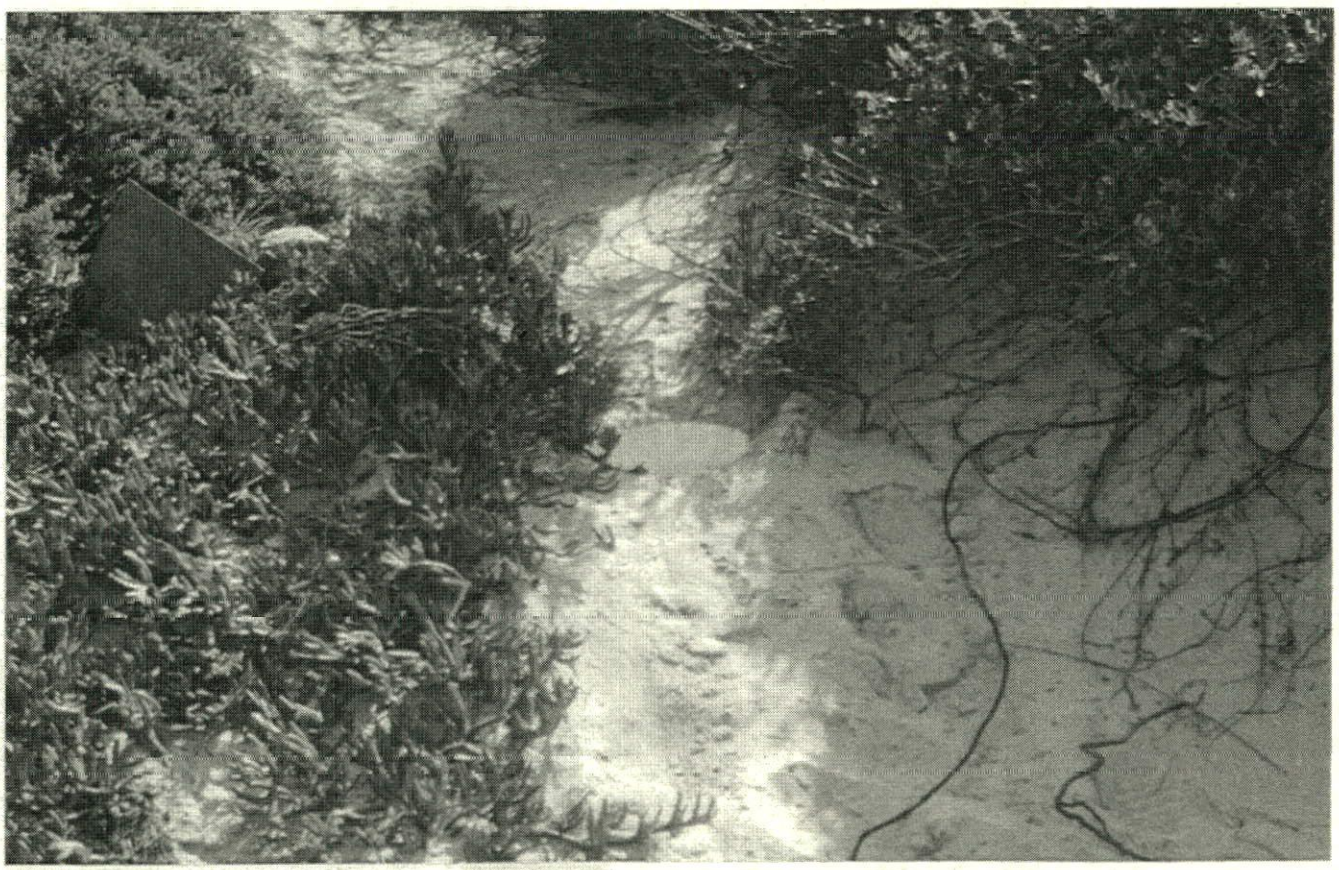
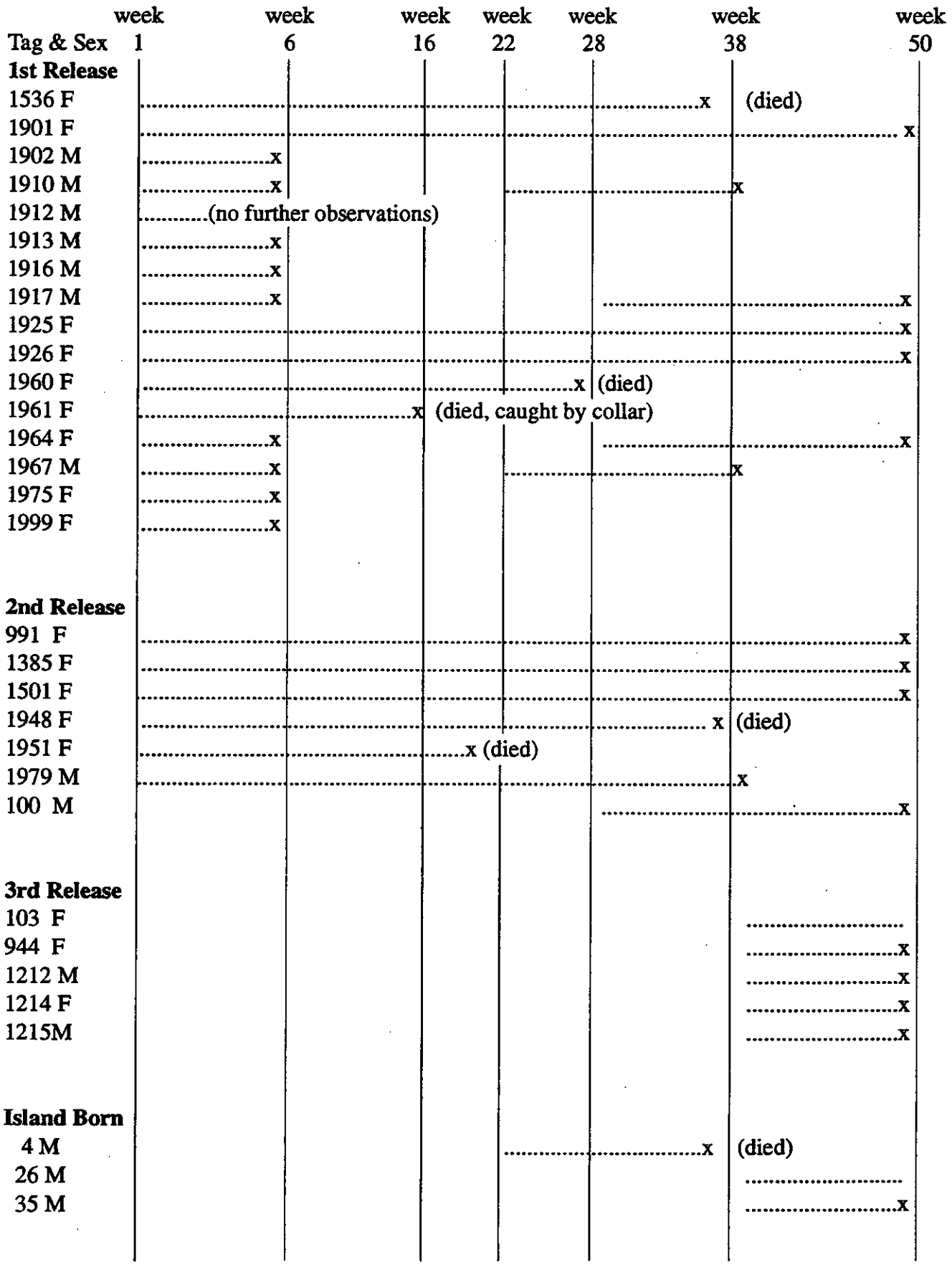


Figure 11 Pitfall trap positioned on a ***Leporillus*** run (or pathway), closed-in on its sides with an informal barrier of twigs

TABLE 2. Periods for which *Leporillus conditor* were fitted with radio transmitter collars, Reevesby Island, September 1990 - September 1991 (x signifies retrieval of collar-radio: several animals recollared throughout study)



OTHER CAPTURE METHODS

Further observations and captures of collared and uncollared rats were obtained using up to 110 Elliott traps baited with peanutoatmeal or carrot pieces and by spotlighting. Also up to 45 pitfall traps (depth 65 cm, diameter 25 cm) were used. Five lines of pitfalls (515 pits per line at approximately 40 m spaces), were established progressively during the study (see Fig. 6). The labour-intensive use of 25 cm high mesh fencing between pit traps was dispensed with when it was found (from tracks) that rats had probably jumped over this barrier on one or more occasions and that a good capture rate of *Leporillus* was obtained when no fence was used. To increase the rate of capture further, pitfalls were sited in known *Leporillus* pathways (or runs), as shown by their tracks, or in sites likely to be used as runs. These were frequently placed in narrow open areas between shrubs, with the pathway further restricted using a few leafy twigs or sticks so that the open path passed directly over the pit (see Fig. 11).

All released rats and subsequently captured island-born rats were tagged with numbered monel eartags. Data from captures and sightings by all methods have been pooled for analysis of home ranges, movements, reproduction and dispersal of young. The location and identity (if known) of each rat observed and the type of shelter it used (i.e. bush size and species, rocks, building etc.) was recorded. Initially, locations of *Leporillus* were plotted giving distance and direction from their site of release. Later a 700 m x 300 m grid using 4 m tall bamboo poles at 100 m intervals was set up in the release area in January. All subsequent locations of *Leporillus* in that area were recorded with reference to these. If outside this grid, distance and direction from prominent landmarks (see Fig. 6) were recorded. If captured, rats were weighed and whenever possible sex, weight, pes and skull measurements were recorded, together with the animal's association with, or proximity to, other rats.

The approximate date of birth of island born *Leporillus* which could be measured was determined by comparison with pes measurements of six juveniles from the captive population whose birthdate was known and whose measurements had been taken up to 35 days of age. For larger juveniles, approximate dates of birth were calculated by comparison with weights of known age captive-bred juveniles. This was sufficiently accurate to determine month of birth in most cases but was less reliable once weights exceeded 200g (D. Kennett, Senior Animal Attendant, pers. comm.).

The presence (or absence) and relative age of rat tracks was recorded to further determine the main areas of rat activity and areas occupied or unoccupied.

RESULTS

First Release 24 September 1990,

Locations of all 16 *Leporillus* (7M, 9F) released on 24 September 1990 were determined on one or more occasions during the three days following release. Eleven were located again three weeks after release, on 1617 October. Where possible animals were sighted or their movement detected to confirm that they were alive.

Initial dispersal (distance and direction) appeared to be random, with movements of between 30 m and 1 km occurring within the first three days. Six rats remained within 50 m of their release site after three days.

All of the first release *Leporillus* were recaptured six weeks after release. Half of them were found within 200 m of their release sites, while the remainder had dispersed in all directions up to 1 km south and 3.5 km north (see Figs 12 16). Apart from a male and female found in the same bush in

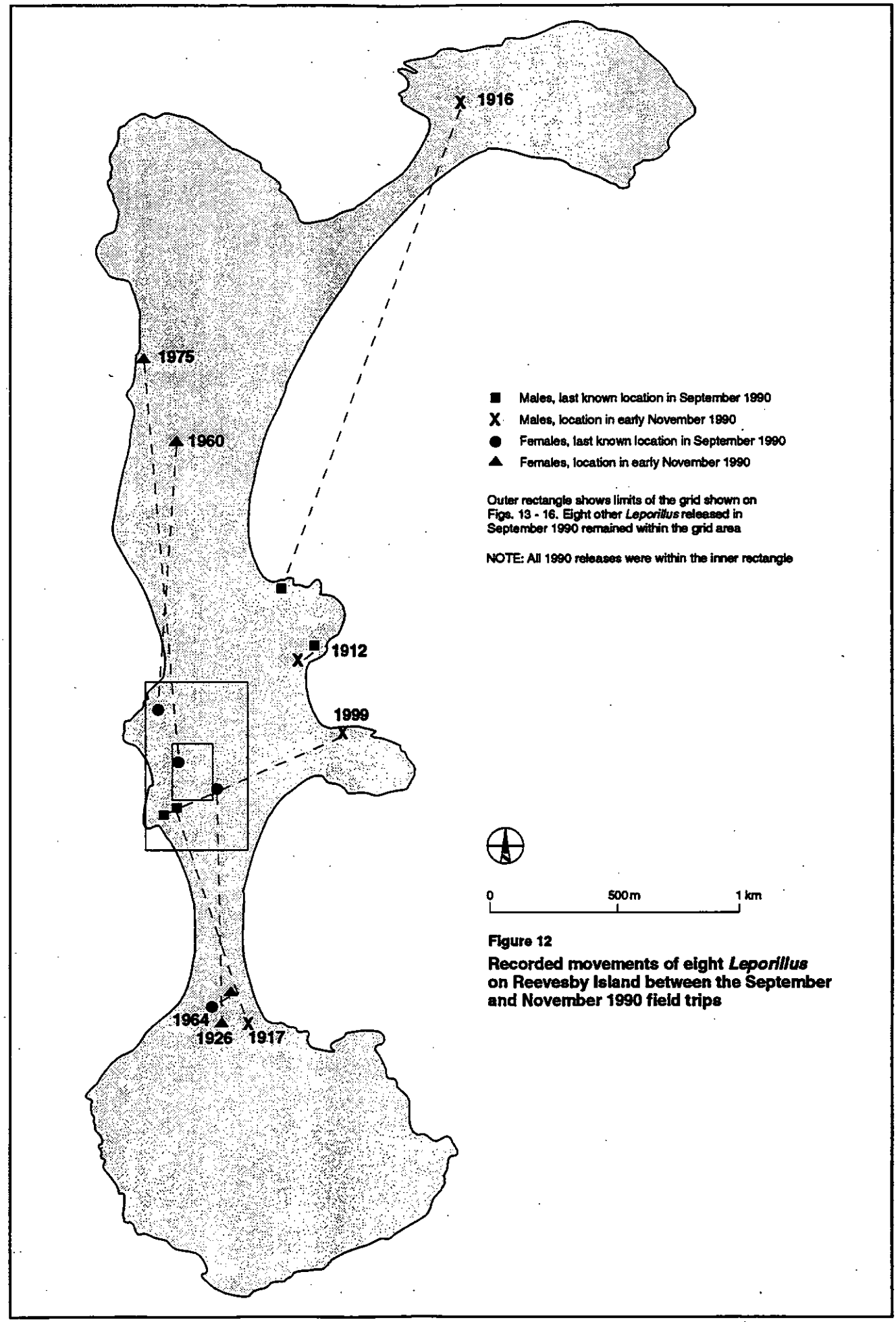


Figure 12

Recorded movements of eight *Leporillus* on Reevesby Island between the September and November 1990 field trips

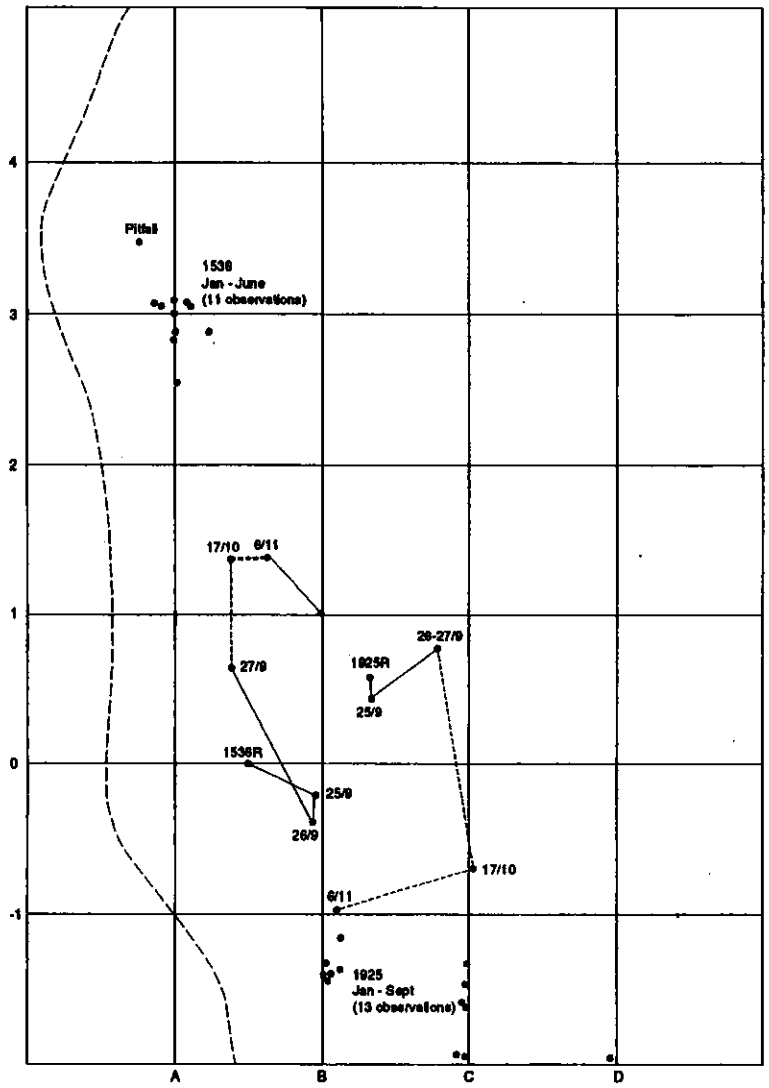


Figure 13

Recorded locations of two female *Leporillus* released on Reevesby Island on 24 September 1990
- no. 1925, 19 observations until September 1991
- no. 1536, 18 observations until June 1991

(Grid 100m x 100m. Dashed line shows high water mark)

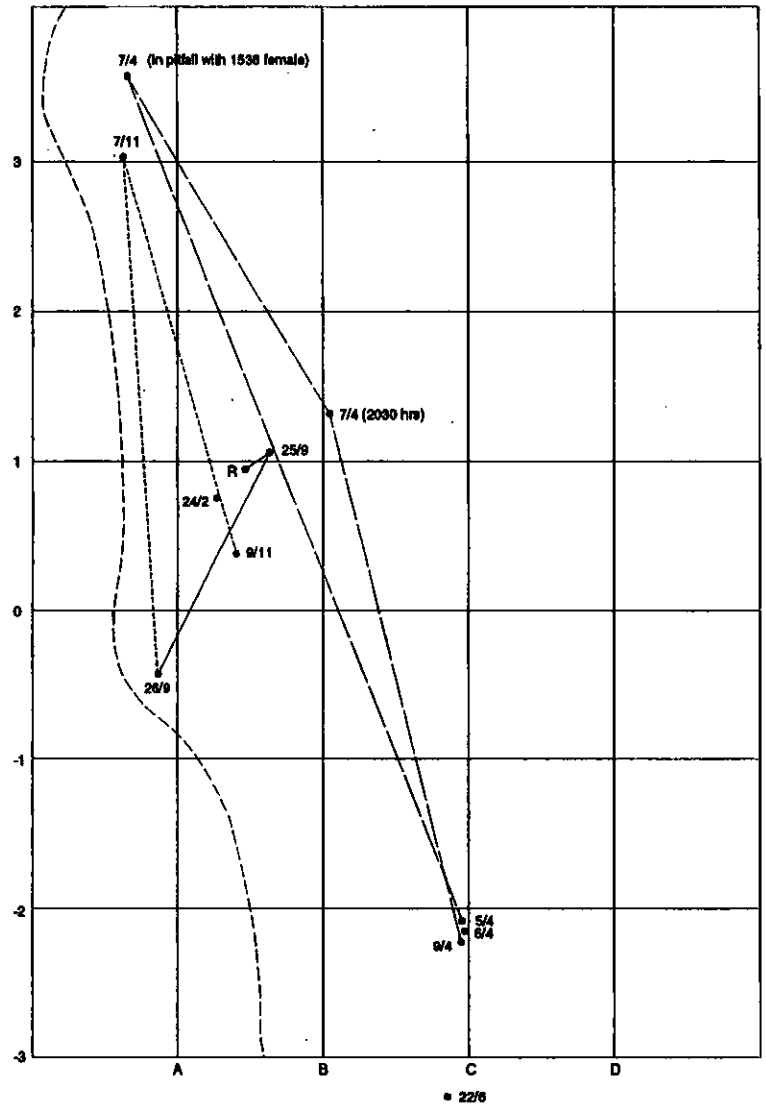


Figure 14

Recorded locations of a male *Leporillus* released on Reevesby Island on 24 September 1990
- no. 1967, 12 observations until June 1991

(Grid 100m x 100m. Dashed line shows high water mark)

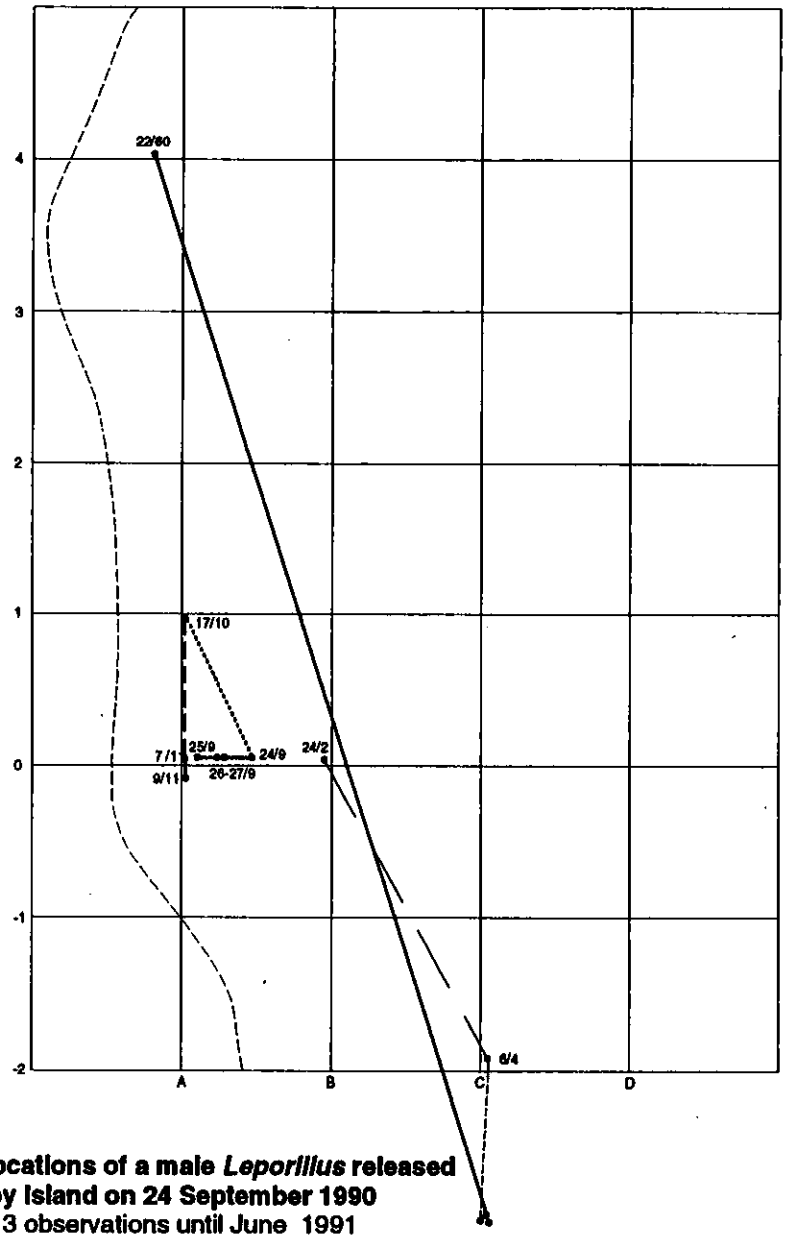


Figure 15

Recorded locations of a male *Leporillus* released on Reevesby Island on 24 September 1990
• no. 1910, 13 observations until June 1991
(Grid 100m x 100m. Dashed line shows high water mark)

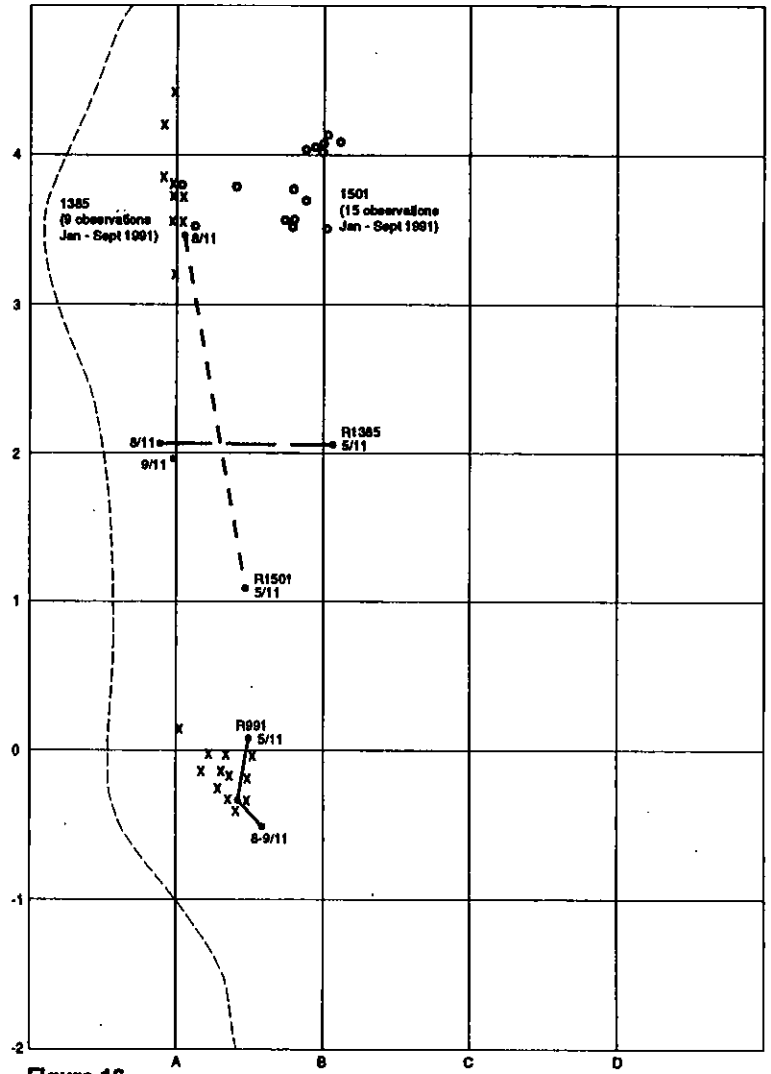


Figure 16

Recorded locations of three female *Leporillus* released on Reevesby Island on 5 November 1990
• no. 991, 16 observations between Jan. and Sept.1991
• no. 1385, 12 observations between Jan. and Sept.1991
• no. 1501, 17 observations between Jan. and Sept. 1991
(Grid 100m x 100m. Dashed line shows high water mark)

the release area, all were alone. Except for two (older and heavier at release) all had gained weight (Figs 17 and 19). Two had occupied limestone and granite crevices near the high water mark, one had occupied the space beneath the wooden floor of the old shearing shed (where it was reliably found for the rest of the study) and the others were all found within the densest available shelter within large shrubs.

Females with attached young and island-born juveniles were found from January 1991 onwards. These observations are discussed below (see Reproduction & Population Increases).

Second Release 5 November 1990.

Sixteen *Leporillus* (5 M, 11 F) were released on the original release grid on 5 November 1990. Six of these (1 M, 5 F) were fitted with transmitter collars at release. Four females were subsequently observed for periods of up to 45 weeks on the low coastal dune near their point of release (991, 1948) or 200300 m north of their release site (1385, 1501), on the coastal dune and in nearby shrubland (see Fig. 16). The male (1979) initially moved 200 m north of its release site then was not found until 20 weeks later about 1 km further north. Several observations in April and June showed that it moved between sites up to 1 km apart in that area. One female (1951) was not found until recovered dead 16 weeks after release about 500 m east of its release site. Cause of death was not known.

The **only** observation of the ten 'second release' *Leporillus* which did **not** have transmitters was of a female (1911) which was caught in a pitfall within 100 m of its release site 32 weeks after release and noted as "?preg (nipples enlarged)".

Third Release 18 June 1991

Forty two *Leporillus* (22 M, 20 F) were released on 18 June 1991, on the southern part of Reevesby Island, approximately 500 m south-east of the old shearing shed, where no evidence of rats had previously been found. (Until June 1991 southernmost observations had been in the vicinity of the old farm buildings.)

At release, after having been placed in boxes for transport about 24 hours earlier, several of these rats showed signs of stress (collapse, gasping) and one died as its collar was being fitted. Most of these rats were quite fat around their necks, which made fitting of collars difficult, so only two of the smaller rats were collared and all were released without weighing or further handling. No evidence of further mortality was found during the next six days, and as well as locating the two rats with transmitters near the area of their release, five rats from this release were caught 500 m -- 3 km north of their release site within 3 - 5 days of release. These rats felt much firmer in condition, probably having lost some weight and three were fitted with transmitters.

Four (2 M, 2 F) of the five 'third release' rats with transmitters were located 12 weeks after release. Both females were with single juveniles born within about six weeks of release. No signal was heard from the fifth transmitter. None of the other 'third release' *Leporillus* was positively identified although two young adult males which had probably lost eartags were caught in the homestead area. These may however have been island-born rats.

Fourth Release 9 September 1991

Twenty seven *Leporillus* (16 M,11 F) were released at the northern end of McCoy Bay in the dunes of the north-eastern end of Reevesby Island where there had been little evidence of earlier released rats. (Since the removal of a transmitter from a first release male (1916) in November very few rat tracks

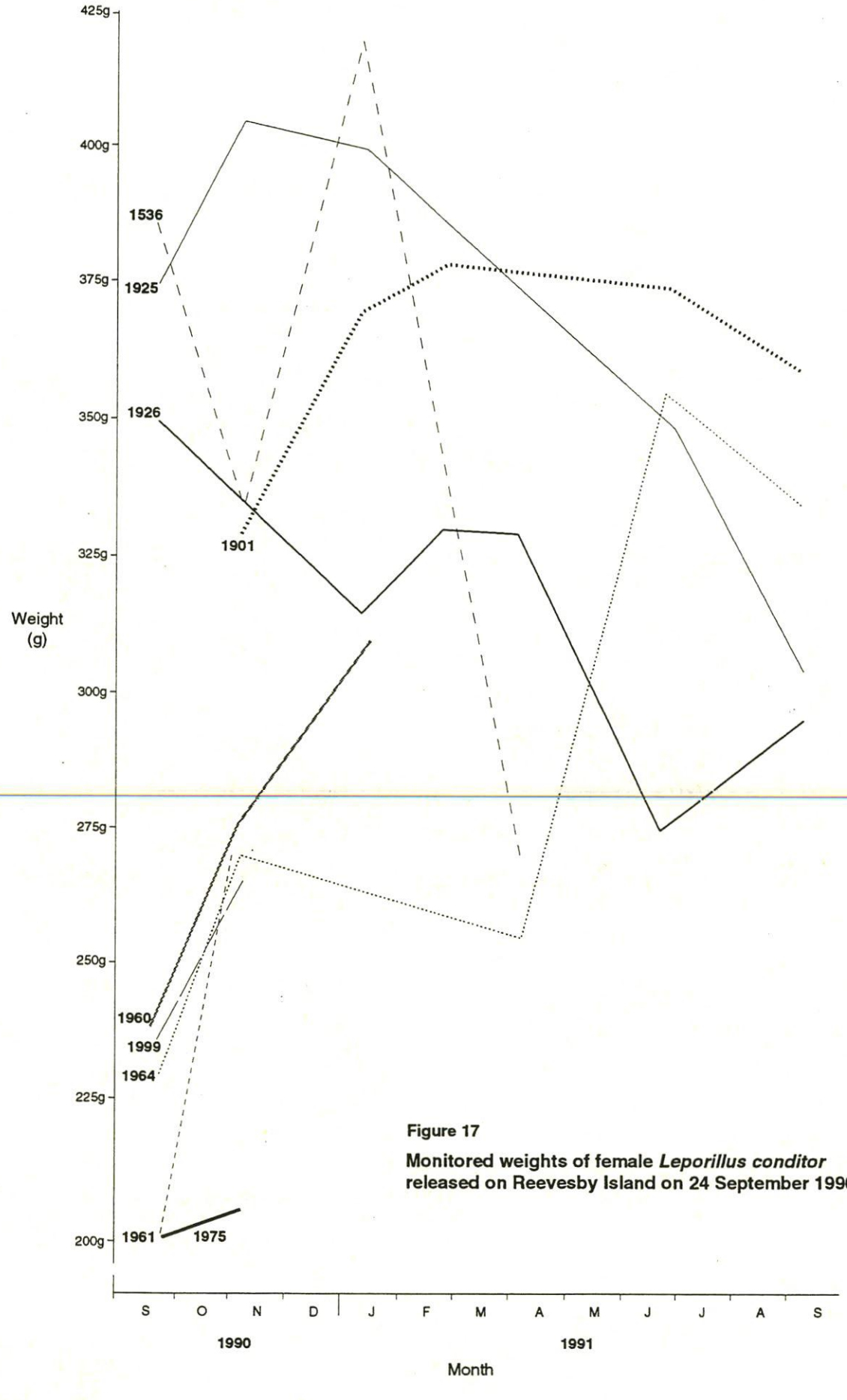


Figure 17

Monitored weights of female *Leporillus conditor* released on Reevesby Island on 24 September 1990

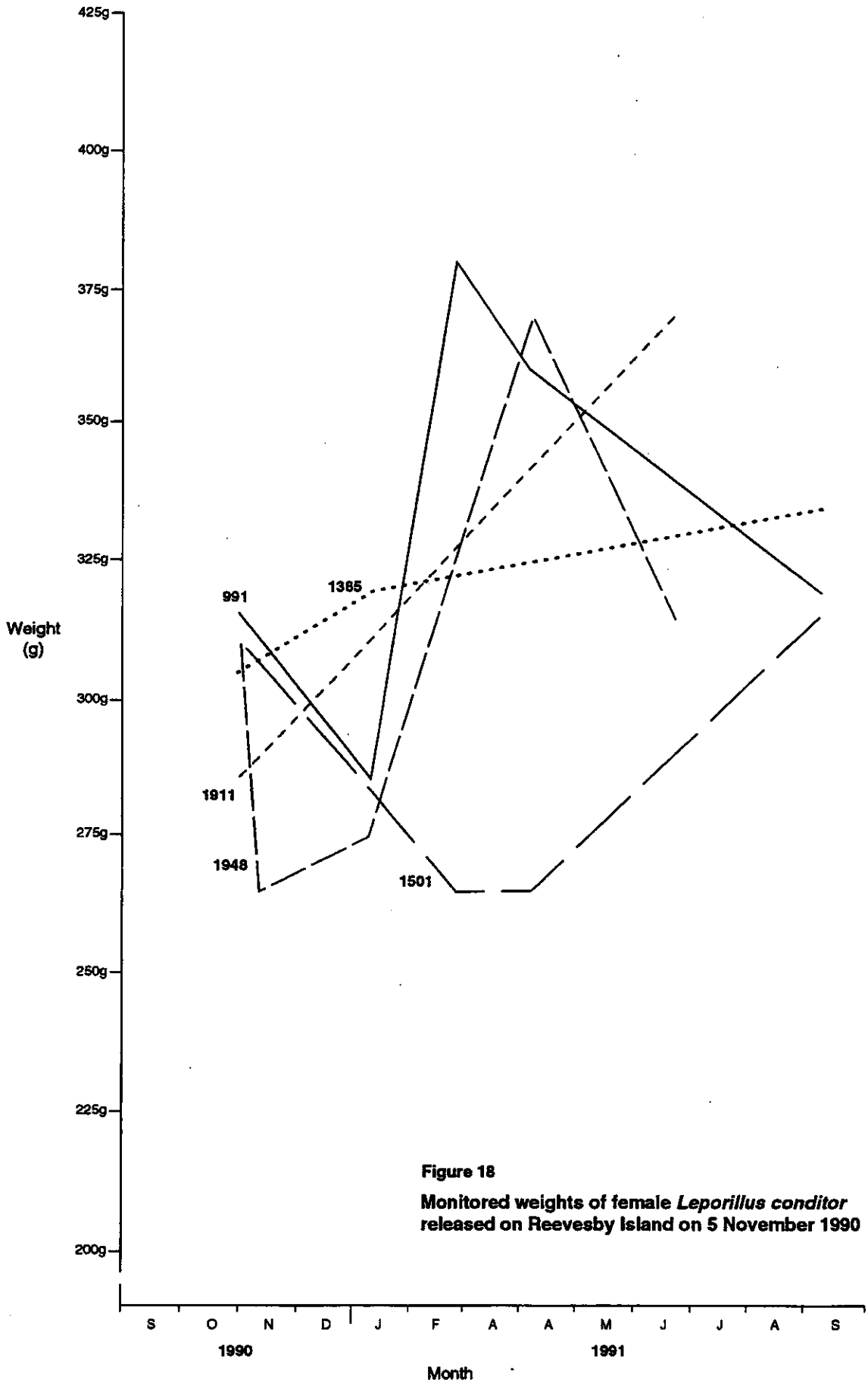


Figure 18

Monitored weights of female *Leporillus conditor* released on Reevesby Island on 5 November 1990

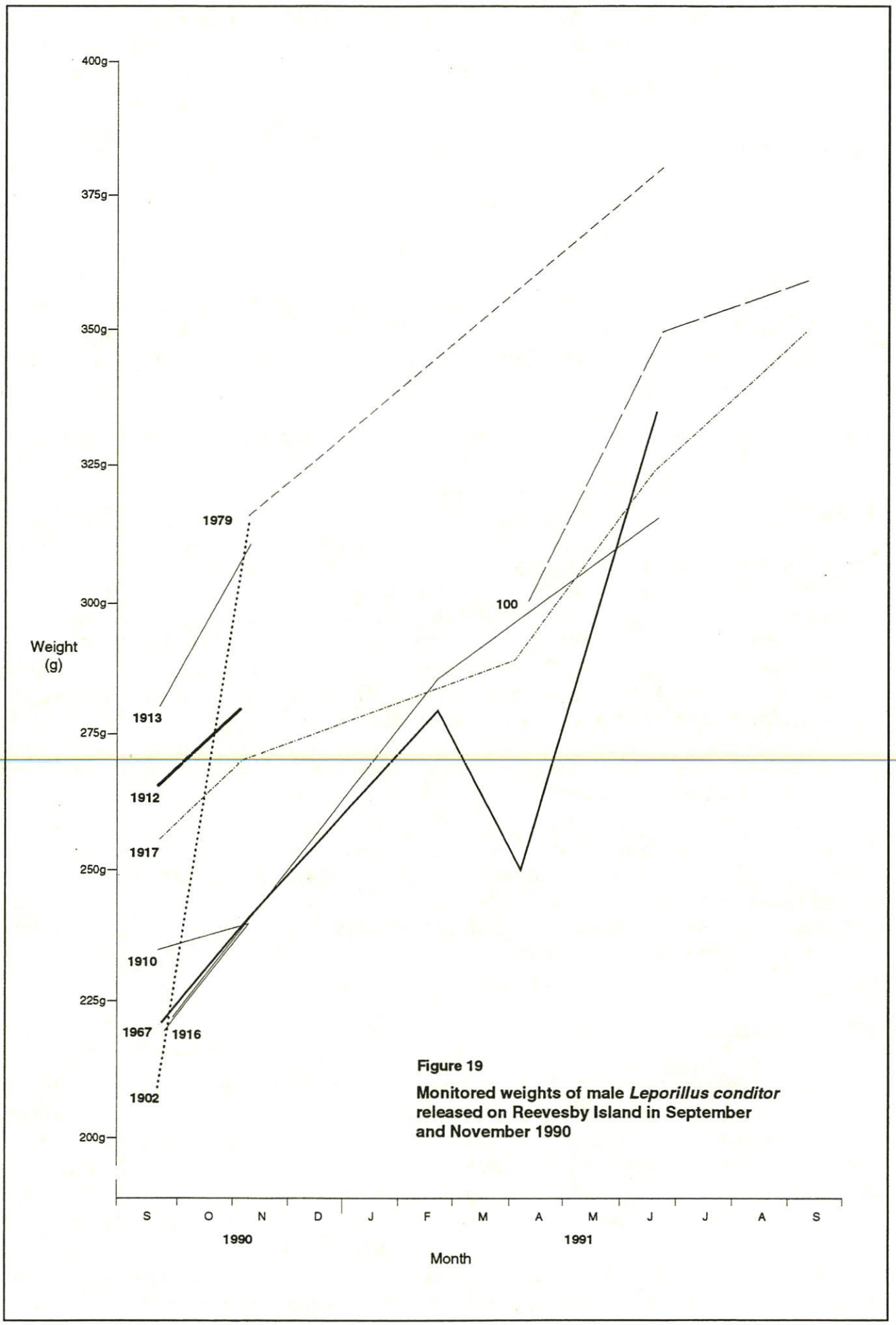


Figure 19

Monitored weights of male *Leporillus conditor* released on Reevesby Island in September and November 1990

had been seen in these dunes.) There were no further observations of these 'fourth release' rats during the next five days, although this was not surprising as none wore transmitters and the nearest trapline was about three kilometres to the south. Several showers of rain had obliterated all but a few tracks in the release area when it was searched one and four days after the release.

No evidence of any rat mortality was found in the release area, (although one rat had died in transit, some hours before the release).

PITFALL TRAPPING RESULTS

The most efficient method of capturing *Leporillus* on Reevesby Island was a modified form of pitfall trap (see methods). Capture rates of up to 11% trap success were achieved on nights with little moonlight, whereas bright moonlight as in June resulted in some *Leporillus* avoiding pits (as shown by tracks).

Table 3 summarises captures from the three field trips when most pitfall trapping was done.

ELLIOTT TRAPPING RESULTS

Due to the presence of large numbers of *Mus domesticus* during several visits to the island, Elliott traps were usually occupied within minutes of being set and were therefore unlikely to catch many *Leporillus*. A trial using paired traps baited either with carrot or peanut/oatmeal mixture showed that approximately 10% less mice were caught using carrot bait but captures of *Mus* still exceeded 80% of traps used. For this reason Elliott traps were used mainly in situations where other trapping methods were unsuitable (e.g. among boulders) especially in order to retrieve transmitters. (See also "Accidental deaths and amended monitoring methods" below.)

SPOTLIGHTING RESULTS

Spotlighting using hand-held torches was opportunistic and no set routes were used. Two to four hours were spent in the homestead area and/or the first release area on most field trips. Sightings of *Leporillus* occurred at a rate of less than one per hour. The height and density of shrubs limited observations and only two captures were made as most rats were close to dense cover. The identity or tag status of most other *Leporillus* seen was not determined.

NEST BUILDING

No large stick structures for which this species is named were found on Reevesby Island during this study. Apparently the abundance of large and very densely packed hummocks of *Muehlenbeckia gunnii, Tetragonia implexicoma, Threlkeldia diffusa* and other vegetation provided ample shelter. Indeed the sites used by *Leporillus* frequently included masses of densely packed sticks and twigs, the result of many years accumulation under the canopies of these plants; accumulations which closely resembled the structure of stick-nests built by *Leporillus* elsewhere. Neatly formed entrance holes approximately 5 cm across and near ground level, were observed in several such hummocks covered with living vegetation, where *Leporillus* were located. One such entrance found in January had been covered with a small pile of short sticks when next seen in April, and a

TABLE 3. Summary of Pitfall Captures of *Leporillus conditor* on Reevesby Island, April - September 1991 (bracketed number indicates recaptures within the same trip.)

4 - 9 April 1991

Loc.	No. of pits	Trap nights	CAPTURES Capt. bred	Island-born New captures	Island-born Retraps	Total (%) captures
RAS	5	25				
RAN	5	25	2	1 (1)		4
Dune	5	15	2			2
HS	5	10				
Total	20	75	4	1 (1)		6 (8%)

19 - 24 June 1991

Loc.	No. of pits	Trap nights	CAPTURES Capt. bred	Island-born New captures	Island-born Retraps	Total (%) captures
RAS	5	25	1			1
RAN	5	25	1			1
Dune	10	35	2	1		3
HS	10	26	2(1)	1		4
Total	30	111	6 (1)	2		9 (8.2%)

9 - 14 September 1991

Loc.	No. of pits	Trap nights	CAPTURES Capt. bred	Island-born New captures	Island-born Retraps	Total (%) captures
RAS	5	25		2 (2)		4
RAN	5	25		1	2	3
Dune	10	45		4 (1)		5
HS	15	65	2	2 (1)	3*	8
SRA	10	40		2		2
Total	45	200	2	11 (4)	5	22 (11%)

(* two of these had lost eartags and may have been captive bred.)

new entrance had been formed nearby. This token nest was added to only a little during the remaining five months of the study. In several large natural hummocks of vine and sticks which were taken apart in order to retrieve transmitters from rats, a neat saucer-shaped pad of soft fibrous plant material approximately 15 - 20 cm across had been built in a cavity in the structure. The rat living under the shearing shed floor had also built a similar fibrous pad and was seen on it on several occasions. This is clearly evidence that at least some rats regularly use the same shelters even though "stick-nests" are not built.

HOME RANGES AND MOVEMENTS

Leporillus from the September and November 1990 releases which were monitored after November appeared to have stable home ranges by mid-January (10 - 16 weeks after release). Several were not found further than 100 m from their release point during the 50 weeks of this study. Others remained near the site they occupied within a few days of their release. Figs 13-16 show the areas used by seven *Leporillus* during this study. The core home ranges of two more females (1901, 1948) monitored for 50 and 38 weeks were also confined to less than 1 ha near their release sites. The female (1964) which moved 1 km to dunes near the homestead within three days of release remained within a similar small area for the remainder of the study period. The points plotted are mainly daytime refuges showing that females stayed within a small area, often less than a hectare while males roamed widely, several times covering hundreds of metres in a few hours. The longest overnight movements detected were over 600 m (1967 M) and 800 m (1917 M). Several long series of tracks found on each trip from February to June showed that the latter route north from near the shearing shed was traversed repeatedly for over 800 m, sometimes at intervals of several days, probably by the same male (i.e. 1917).

FEEDING OBSERVATIONS

The areas in which *Leporillus* foraged were not determined as few nocturnal observations were obtained. Twice females were trapped at night 50 - 60 m from their usual daytime shelters suggesting that, as on West Franklin Island (Copley 1988), *Leporillus* may forage away from the core area of their home range which contains their usual daytime shelters. The few nocturnal observations on Reevesby Island suggested that even at night *Leporillus* spent much of their time beneath the canopies of large shrubs, where succulent food plants were abundant and there was little need to search further for food. Possibly many of the numerous trails of *Leporillus* footprints found most mornings were made by males searching for receptive females, or by young animals without fixed home ranges.

Stick-nest rats which inhabited the shearing shed were twice seen foraging within 3 m of the shed at night. They ate boxthorn leaves which they reached from the ground under the shrubs by standing on their hind legs. A female which was found caught by its transmitter collar 1 m from the ground in a boxthorn had probably been foraging although *Leporillus* (including juveniles and females with attached young) also readily climbed with speed and agility among dense, spiky vegetation to evade capture. In September 1991, in several areas, pigface (*Carpobrotus rossii*) fruits and leaves appeared to have been chewed and this was probably done by *Leporillus*.

REPRODUCTION AND POPULATION INCREASES

D. Kennett has provided the following information on breeding age, gestation, and maternal care from his records and observations of the captive population of *Leporillus* in his care at Monarto :

"Juvenile stick-nest rats seem to wean at about 40 days old (i.e. about when the next litter arrives). However young rats occasionally attach to the nipple after this age if there is no subsequent litter."

"Up to about 25 - 30 days, young generally attach to the nipple in response to danger and are dragged around by the female. However they are not always attached even in the first few days and may be found sleeping or crawling about if the female has been surprised by the observer. Females will actually leave the young briefly to go out and feed."

As little as 29, 30 and 33 days interval between litters has been recorded. A further 18 recorded intervals were between 38 and 51 days with various longer intervals also recorded. This suggests a gestation period of as little as 29 or 30 days, much shorter than the 44 days previously recorded (Watts 1982).

The earliest age at which females give birth has been recorded for one female as 100 days with six others between 140 and 150 days.

Reference to the above data from the captive population has allowed a more accurate interpretation of the somewhat fragmented breeding observations of individual females on Reevesby Island.

First Breeding Observed

The first juvenile island-born *Leporillus* were observed on Reevesby Island in January 1991, when two litters were located. These were born in mid- and late December. Notably one of these litters was produced by a 'second release' female only six weeks after release and she was pregnant again. Two other 'first release' and 'second release' females were pregnant sixteen and ten weeks after release respectively. At least two of the females released in June gave birth within about six weeks of release and one of these was pregnant again 12 weeks after release.

Possibly one or more even earlier litters were overlooked as one female which had increased in weight by 30g to 405g by early November, six weeks after release, may have been pregnant (see Fig. 17). Large fluctuations in weights of females (Figs 17 & 18) reflect gains and losses associated with pregnancy and rearing young, but measurements were too infrequent to accurately show fluctuations with each litter. By contrast weights of males steadily increased (see Fig. 19) with the only loss of weight observed being associated with a 600 m movement and loss of feeding opportunity while in a pitfall the previous night.

Figure 20 shows that at least 57 island-born juvenile *Leporillus* were found on Reevesby Island during 1991 within a year of the first release. These young were produced by females released in September and November 1990 and June 1991. Nine females (12 individuals) wearing transmitters were regularly observed for nine months from December 1990 to September 1991 and these produced a total of 42 known young (33 tagged/earmarked) from 27 litters as follows : 14 singles, 11 twins, 2 triplets, mean litter size 1.56. One female (1901) produced 10 known young from five litters, including two litters of three. Two others (1501, 1948) produced at least four litters and totals of six young each.

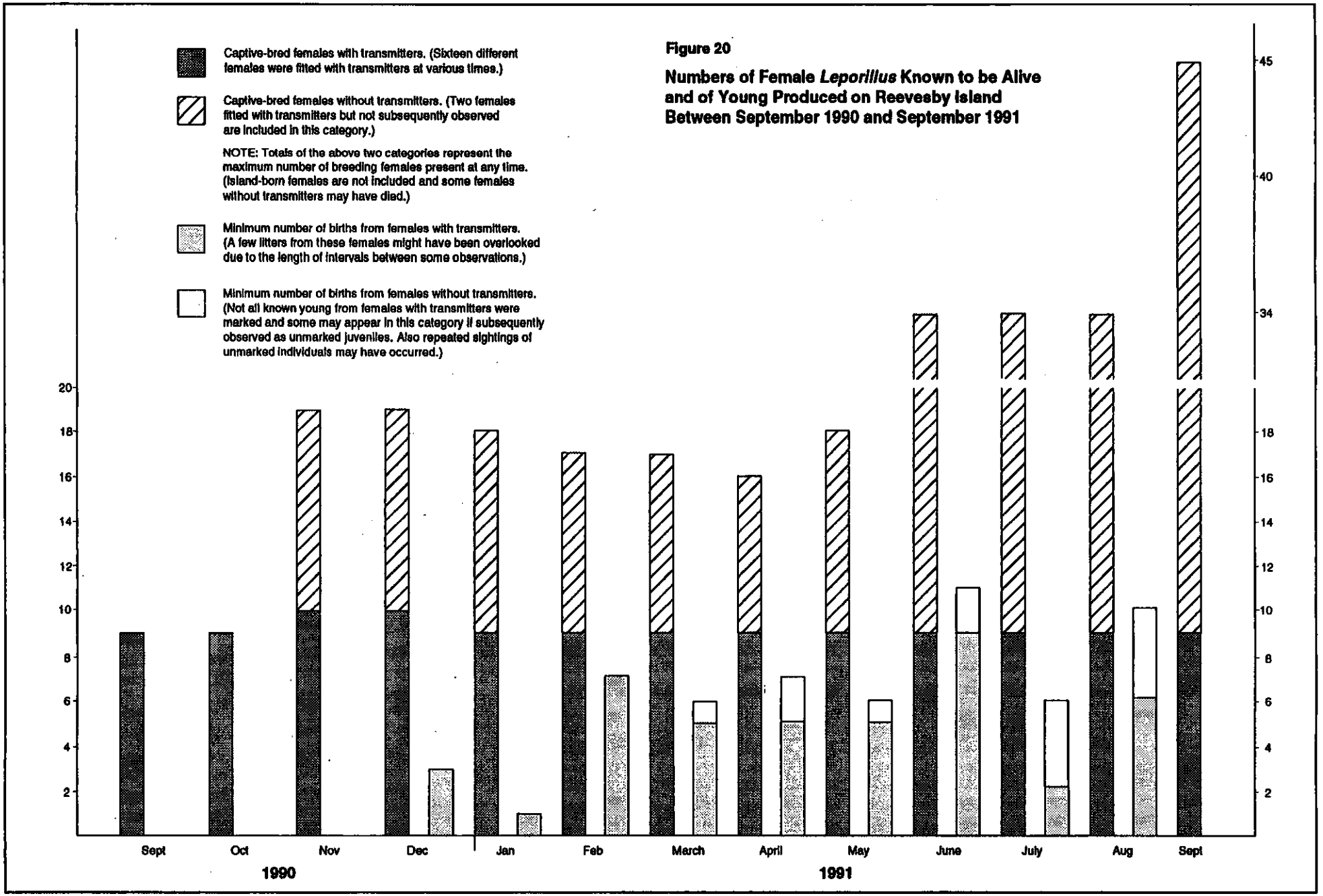


Figure 20

Numbers of Female *Leporillus* Known to be Alive and of Young Produced on Reeveaby Island Between September 1990 and September 1991

At least six further pregnancies were known or suspected from these females during the same period which, if calculated at the mean litter size, is nine further young or a total of 51 young from nine females during nine months. A mean annual production per breeding female of 7.56 young can be calculated from the above data.

No young were detected with females not wearing transmitters. This is not surprising since only one such female was recaptured, whereas the females with transmitters were each observed or captured up to 21 times during the same period. However, 14 unmarked island-born *Leporillus* were trapped and others seen but not caught. As not all young of collared females had been marked the provenance of such unmarked young was uncertain, but it is likely that most were progeny of females without transmitters. During the period from December 1990 to September 1991 these uncollared females comprised, on average, about half of the breeding females present on Reevesby Island and therefore are also likely to have produced a total of approximately 50 young by September 1991.

Table 1 does not include the small but increasing number of island-born females reaching breeding age from mid-1991 onwards. The unknown number of deaths of females released without transmitters is likely to have been approximately offset during mid-1991 by the number of island-born females reaching breeding age. While few data are available on mortality rates of young *Leporillus* on Reevesby Island, it is estimated that, with the release of 11 more females in September 1991 and the recruitment of at least some island-born females to the breeding population, the total population of stick-nest rats on Reevesby Island by the end of 1991 was in excess of 200 individuals and increasing. With the increased number of females resulting from releases in June and September 1991, combined with further island-born females reaching breeding age there will have been more rapid population increases from late 1991 onwards.

DISPERSAL OF YOUNG

Young *Leporillus* were found with or near their mother (in the same shelter) up to the age of four months. In three instances even when the female had attached young, juveniles aged 10 weeks to four months from an earlier litter were still present. Twice by chance it was found that juveniles aged six and 12 weeks were not with their mother but in adjacent shrubs into which the female had been flushed from her original location. Other such family groups dispersed among several nearby shrubs could have readily been overlooked through the usual capture method of surrounding only the shrub in which the transmitter signal was detected.

In three instances females seen or caught with attached young (age 16 - 20 days and 30 days) were trapped without their young on subsequent nights, apparently having left them while foraging, as noted by Kennett for captive animals. Young are likely to be most vulnerable to predation by snakes when left alone at this age.

The single male (4) and female (17) offspring (separate litters) of the female inhabiting the shearing shed were seen in or near the shed up to ages four and three months respectively. The male at four months had spent two days 120 m away but was in the shed again during the next three days. His collar and some fur were found 12 weeks later 4 km to the north but the animal may have been carried at least part of that distance by a Southern Boobook *Ninox novaeseelandiae*. The female (17) appeared to be pregnant when caught in the shed at three months. Another island-born female (6) caught when six months old was obviously pregnant and had moved 300 m north of the site where it was tagged as an attached young.

A juvenile male (23) aged 12 weeks was caught within 20 m of the site where it was tagged as an attached young a few days old.

Two island-born male *Leporillus* caught when about 12 - 14 weeks old were fitted with transmitters. Twelve weeks later one (26) was caught in the same pitfall trap and the other (35) had moved 1.5 km southwards.

HABITATS USED

The great majority of observations were made in shrubland on sandplain and dune areas which included and adjoined the release areas. Only five *Leporillus* were found using the rocky shores. The extensive grassland areas were only used briefly by a few rats within a few days of their release. However tracks were not easy to find in these areas and some use by uncollared *Leporillus* may have been overlooked.

Most activity (as judged by fresh tracks found each morning) was concentrated in the dunes along the western edge of the release area and by February and April in the higher dunes south and east of the release area. Tracks (Fig. 21) indicated that several *Leporillus* continued to live in the dunes near the homestead and shearing shed and at several scattered sandplain sites north of the release area. The remaining major areas of shrubland at the northern and southern ends of the island remained little used or unoccupied until the third and fourth releases were made, even though some *Leporillus* had proven their ability to cover the distances necessary to reach those areas.

Figure 21 Characteristic tracks of *Leporillus conditor* now found in most sandy areas of Reevesby Island

STRESSES, MORTALITY & PREDATION

A low mortality rate was found among released *Leporillus* and their progeny, and unfortunately some of this was caused by the monitoring methods. However, little useful data could have been collected without the use of transmitters and pitfall traps and some modification of equipment and methods was done to minimise further losses. Probable causes of death of the 10 Leporillus found dead during this study are listed below. (Note that six of these would not have been found had transmitters not been used.) Changes to monitoring methods, either tried or proposed, are also discussed below.

Deaths in transit

Only two of 103 *Leporillus* taken to Reevesby Island died before release (see third and fourth releases). Whenever logistically possible travelling time and handling at the point of release should be kept to a minimum (e.g. transmitter collars should be fitted some days before release as was possible with the first release).

Weight losses in transit and in traps

One 'second release' female was caught in a pitfall trap four days after release, having lost 45g since it was weighed a week before release (310g). This represents the combined effects of transport and release and lost feeding opportunity while in the pitfall. No other newly released *Leporillus* were handled until six weeks after release and most of these had more than regained any weight losses associated with transport and release. Other *Leporillus* caught on two or three consecutive nights in pitfall traps typically lost 15 - 20g per night, while one captured during the day weighed 135g, 30g more than it had 24 hours earlier when caught in a pitfall, clearly having made up for lost feeding opportunity the previous night. Some compensation for lost feeding opportunity for *Leporillus* caught in pitfalls may be gained by placing a large piece of carrot (e.g. 50 g) in each pit. (Carrot is less likely to attract ants and mice than peanut/oatmeal mixture and was used successfully as bait for *Leporillus* in Elliott traps when *Mus* were abundant. Carrot-baited Elliott traps caught approximately 10% less *Mus domesticus* than peanut/oatmeal baited traps in trials on Reevesby Island in January 1991 when *Mus* numbers were at their peak.)

Accidental deaths and amended monitoring methods.

1961 female : caught by collar on boxthorn spine. Surplus length of transmitter straps with extra adjustment holes were subsequently trimmed and remainder bent flush with collar when new collars were fitted.

1948 female : died in Elliott trap, presumed stress and cold (soaked in urine). Several other *Leporillus* caught in Elliott traps were soaked in their urine and appeared stressed. Use of Elliott traps should be limited. They should be placed in sites well protected from wind and contain plenty of absorbent material (e.g. dry grass or seaweed).

Juvenile : trampled in pitfall by penguin (another juvenile was caught unharmed in a pitfall which also contained two penguins). Short pieces of p.v.c. tube large enough for a *Leporillus* to enter, placed in the bottom of pits, should offer some protection from other pitfall occupants.

Juvenile : accidentally crushed by hand net rim at capture. Where possible, use of hand nets was avoided in favour of capture by hand, especially with females which had small attached young.

Twice small young were dislodged from nipples when caught in hand nets, but were later successfully reunited with their mothers.

Of three collared females found dead (1536, 1960, 1951), two were in very dense vegetation and might have been caught by their collars. The other was on open ground between shrubs with no cause of death evident.

Juvenile : dried carcase found adjacent to a bush used several times by 1385 F. The cause of its death was unknown.

Evidence of Predation and likely Predators.

Two *Leporillus* were believed taken by owls. The transmitter and some tufts of fur of a young island-born male were found in June with several cast pellets (containing *Mus* remains) of a Southern Boobook. These were located under a large boxthorn over 4 km north of the area this rat used in April. Whether it moved itself or was carried by an owl cannot be determined.

A recently predated, headless, inverted *Leporillus* skin was found near the shearing shed in September 1991. This typical Barn Owl feeding pattern (personal observations, Franklin Islands) was confirmed by several sightings of one or more Barn Owls in this area during that period.

Other possible predators of *Leporillus* observed on Reevesby Island during 1990 and 1991 included Black-shouldered Kites *Elanus caeruleus*, up to six of which were present for much of 1991, presumably feeding on the abundant *Mus domesticus*. (Cast pellets from below a frequently used perch near the homestead contained only *Mus* remains). These kites often hunted until well after sunset and could potentially take *Leporillus*, as they are known to take mammals up to the size of small Rabbits *Oryctalagus cuniculus* (Cupper and Cupper 1981). Other raptors observed (White-bellied Sea Eagle *Haliaeetus leucogaster*, Brown Falcon *Falco berigora*, Australian Kestrel *Falco cenchroides*, Spotted Harrier *Circus assimilis*, Swamp Harrier *Circus approximans*) are unlikely to be significant predators of *Leporillus*.

Black Tiger Snakes *Notechis ater* and Death Adders *Acanthophis antarcticus* will presumably take some *Leporillus* although no evidence of this has yet been found on Reevesby Island. No evidence was found of goannas *Varanus* sp., previously present (introduced) on Reevesby Island (Robinson et al 1985).

FUTURE PROSPECTS

With an estimated population in excess of 200 by the end of 1991 there are still large areas of Reevesby Island which appear unused or thinly populated by *Leporillus*.

There has been little use observed of grassland areas by *Leporillus* to date and the future population size will, in part, depend on the extent to which this habitat is used. However, even with limited use of such areas it seems that the potential exists for the population on the 344 ha of Reevesby to be greater than on the larger area of the Franklin Islands as there is more, dense cover to afford greater protection from predators (i.e. owls) and negligible habitat disturbance by burrowing petrels.

The very high population and subsequent crash in numbers of *Mus domesticus* seemed to have no adverse effects on *Leporillus*.

It remains to be seen whether there is any modification of present habitats by increased numbers of *Leporillus* or Cape Barren Geese *Cereopsis novaehollandiae* (Robinson and Delroy 1986) and even if such changes occur, whether they will benefit or adversely effect other species.

ACKNOWLEDGEMENTS

We thank the numerous volunteers and NPWS personnel from Eyre district, Monarto Fauna Complex and Biological Conservation Branch who have participated in this project and in fieldwork under sometimes difficult conditions.

We especially thank Chris Elliott and Mick Francis and their families, of Sea Jade Charter, for their generous hospitality and friendly, reliable and efficient service in all weather.

REFERENCES

Copley, P. (1988) The Stick-nest Rats of Australia. Report to World Wildlife Fund. NPWS, Adelaide.

Cupper, J and Cupper, L. (1981), Hawks in Focus, Jaclin Enterprises, Mildura.

Pedler, L. (1991), Feral Cat Eradication on Reevesby Island, South Australia. (Report to WWF, Project No. 175, Reintroduction of Sticknest Rats, Phase 1.)

Robinson, A.C. and Delroy, L.B. (1986). Monitoring of Cape Barren Goose Populations in South Australia. South Australian Ornithologist **30**:4551.

Robinson, A.C., Mirtschin, P.J., Copley, P.B., Canty, P.D. and Jenkins, R.B. (1985). The Reevesby Island Goanna - A Problem in Conservation Management. South Australian Naturalist **59** (4): 56-62.

Watts, C.H.S. (1982), The Australian hydromine rodents: maintenance of captive colonies. In the management of Australian mammals in captivity. (ed. D.D. Evans) pp.180184 Proc. Scientific Meeting Aust Mammal Soc. Victoria, 1979. (Zool. Board of Victoria.)