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FERRET POPULATION ASSESSMENT: PROGRESS AND CHALLENGES

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ABSTRACT: Ferrets are an invasive species especially common in New Zealand farmland. Ferrets become infected with bovine tuberculosis by feeding on infected carrion, and may also be a wildlife reservoir of the disease when their density, averaged through the year, exceeds a threshold of about 3 per km^2. Reliable knowledge of ferret density is therefore useful for disease managers. Obtaining such knowledge is difficult because ferrets are highly mobile and estimates are required for large areas (>20 km^2). We describe the results of 11 field trials of a new spatially explicit capture-recapture method implemented in program DENSITY. Ferrets were captured, marked and released over 6 days in 130–170 live traps per study area (16.8–42.1 km^2). Estimated density ranged from 0.8 per km^2 (SE 0.2) to 6.9 per km^2 (SE 0.9). Relative precision (SE(Estimate)/Estimate) ranged from 6% to 29%. Home-range size varied inversely with density; this effect could be expected to bias comparisons based on conventional estimators that use an effective trapping area. Some marked ferrets were caught repeatedly at a particular site, which suggests a lack of fit to the spatially explicit detection model. However, an improved method implemented in version 3.2 of the DENSITY software appears robust to this effect. Two problems require further consideration: extrapolation from the trapped sample to a management area requires the assumption that the sample is spatially representative. Ordinarily this can be ensured by random placement of lines, but topography and difficulties of access usually make random placement unacceptably expensive. We also encountered problems with occasional dispersal movements. We suggest that ferret monitoring be undertaken at times of year when little dispersal is expected.

INTRODUCTION

Ferrets are an invasive species especially common in New Zealand farmland, where they prey on introduced rabbits and a variety of introduced and native fauna. Ferrets become infected with *Mycobacterium bovis* (bovine Tb) by feeding on infected carrion (Lugton et al. 1997). At low densities ferrets are likely to be 'spillover hosts' of bovine Tb. However, at higher densities ferrets have the potential to be a maintenance host of the disease. This is currently thought to occur when their density, averaged through the year, exceeds a threshold of about 3 per km^2 (Caley and Hone 2005). Reliable knowledge of ferret population density is therefore useful for disease managers.

Determining population density is difficult because ferrets are highly mobile and estimates are required for large areas (>20 km^2). Trap-catch indices have been advocated for ferrets (Cross *et al.* 1998). These rely on the strong assumption that trappability and home range size remain constant in space and time. Uncalibrated indices do not provide a measure of population density. Cross *et al.* (1998) provided a calibration of trap catch for ferrets, but as this was based on a single site at a single time it does not provide useful information about the reliability of the index.

The conventional method for estimating population density D has been to use capture-recapture or removal trapping to estimate a population size N, and to divide N by the 'effective trapping area' ($D = N/A$). This method suffers from severe problems because A is not clearly defined, and the methods for estimating A are either *ad hoc* (boundary-strip widths from trap-revealed movements) or too expensive for general application (radiotelemetry).

New spatially explicit methods have been suggested for analysing capture-recapture data (Efford 2004a, Efford *et al.* in press a,b). These methods avoid the particular problem of estimating A by fitting a model to the capture-recapture data that has parameters only for density D and a spatial detection function. We apply the methods to data from ferret trapping and discuss issues that arise.

METHODS

1. Field trials

Eleven field trials were conducted in central Otago between February and May 2003 using Holden live traps baited with rabbit meat. Traps were set at spacings of 150–300 m mostly along tracks and ridges accessible by farm bike, with 130–170 traps per study area (16.8–42.1 km^2) (Fig. 1). Ferrets were captured, tagged in both ears, and released over 6 days. Norbury and Efford (2004) provide further details.

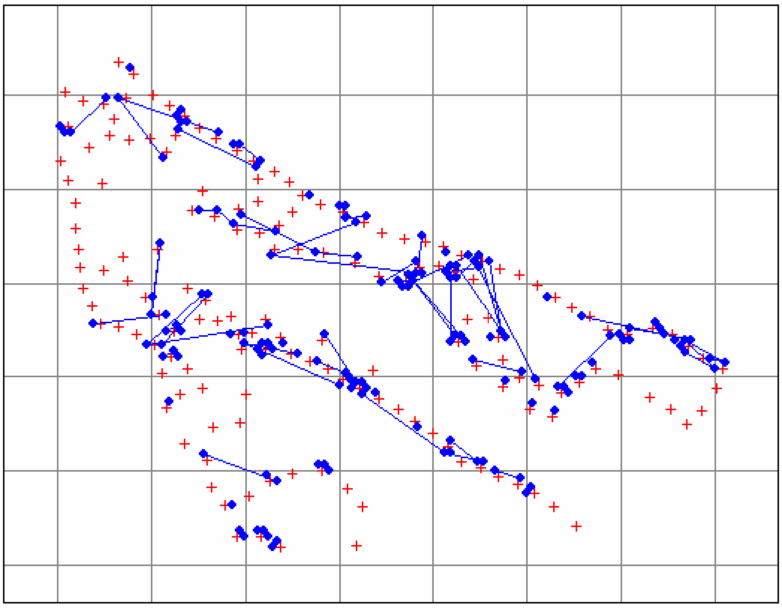

Fig. 1. Example of ferret capture–recapture on area P1. Crosses indicate trap sites (159 traps, average spacing 225 m) and dots indicate capture sites of ferrets over 6 days. Capture sites are displaced slightly from true location to reduce overlap. Lines connect consecutive captures of individual ferrets. 1-km grid.

2. Data analysis and software

We expected field data collected over each 6-day trapping session to be suitable for 'closed population' analysis in the sense that negligible recruitment or loss occurred over the period of trapping (Otis *et al.* 1978).

The spatially explicit capture-recapture approach models the observed capture data in terms of population density D and a spatial detection function $g(r)$ where r is the radial distance between a home range centre and a trap (Efford 2004a). We used a half-normal detection function, with parameters $g(0)$ (capture probability in a single trap at home range centre) and σ (spatial scale over which capture probability declines). Home-range centres were assumed to follow a 2-D Poisson distribution, and to be fixed for the duration of trapping. The model was fitted by an indirect, computer-intensive method (simulation and inverse prediction; see Efford 2004a,b for details). Simulated populations extended 3 km beyond the traps in all cardinal directions to ensure that all potentially trappable animals were simulated. Inverse prediction used conventional population estimates *N*-hat and *p*-hat to predict *D* and *g*(0), and a pooled measure of the spatial variance of individual capture locations to predict σ. We report the sampling error of *D*-hat adjusted for the spatial variance of a 2-D Poisson process (Efford 2004b).

RESULTS AND DISCUSSION

Table 1 Ferret population density estimated by spatially explicit capture-recapture for 11 sites in central Otago trapped between February and May 2003. *g*(0) and σ are detection parameters explained in the text. Standard errors (in parentheses) and confidence intervals for density were adjusted to exclude spatial variance.

Study area	Number tagged	Number of recaptures	Density km^{-2}	95% confidence interval for density	*g*(0)	σ (m)
T1	52	76	4.7 (0.6)	3.4–6.0	0.105 (0.022)	305 (20)
T2	46	63	2.6 (0.4)	1.8–3.5	0.049 (0.013)	525 (41)
B1	109	187	4.8 (0.3)	4.2–5.4	0.216 (0.031)	327 (13)
B2	62	79	1.5 (0.2)	1.1–1.9	0.037 (0.009)	765 (73)
B3	73	141	3.9 (0.3)	3.2–4.5	0.163 (0.034)	355 (22)
C1	118	98	6.9 (0.9)	5.2–8.7	0.048 (0.010)	402 (24)
C2	64	27	6.4 (1.7)	3.1–9.8	0.030 (0.010)	323 (40)
C3	43	21	3.8 (1.1)	1.6–6.0	0.014 (0.006)	439 (75)
P1	78	73	3.4 (0.4)	2.7–4.1	0.082 (0.016)	392 (24)
P2	30	39	0.8 (0.2)	0.5–1.1	0.040 (0.018)	791 (117)
P3	63	101	2.0 (0.2)	1.7–2.3	0.087 (0.016)	503 (26)

The method gave apparently precise estimates of absolute density (Table 1). Relative precision was good (SE(Estimate) / Estimate < 20%) except when few (<40) recaptures were obtained. Home-range size (measured by σ) varied inversely with density (Fig. 2). Failure to allow for the high and varying mobility of ferrets will make conventional estimates unreliable.

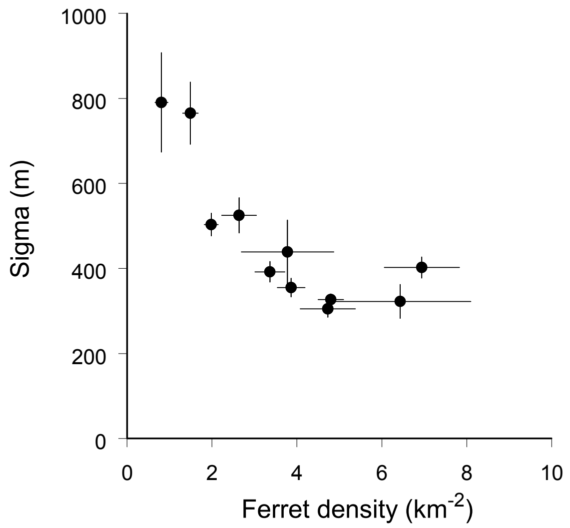

Fig. 2. Relationship between estimates of σ, a linear measure of home-range size (a circle of radius 2.45σ is expected to include 95% of activity for a circular normal home range), and ferret population density (± 1 SE). Each point represents a separate population (data in Table 1).

No correlation was found been between density and subsequent trap-catch by contractors in the same areas (Fig. 3).

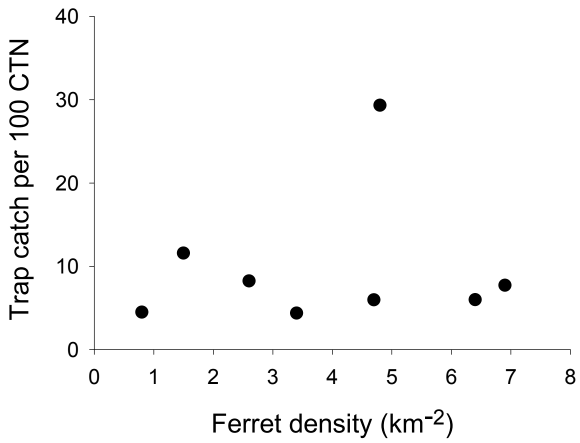

Fig. 3. Relationship between density estimated by intensive live trapping and subsequent trap catch over 3 nights removal trapping by contractors. (See Norbury and Efford (2004) for details)

Ferrets appear well-suited to spatially explicit capture-recapture in that they are trappable, easily handled, and highly mobile. Some marked ferrets were caught repeatedly at a particular site, which suggests a lack of fit to the spatially explicit detection model. Simulations lead us to believe this particular violation causes only minor bias when a suitable statistic is used to summarise movement (e.g. spatial variance of individual capture locations; Efford 2004b). However, two problems require further consideration:

1. Extrapolation from the trapped sample to a larger management area requires the assumption that the sample is spatially representative. This applies to any method based on intensive sampling of just part of the area of interest. Ordinarily, representativeness can be ensured by random placement of lines (e.g. protocol for possum trap catch index. National Possum Control Agencies 2004), but topography and difficulties of access usually make random placement expensive on the scale required for ferrets. An alternative approach is to avoid

extrapolation altogether by limiting inference to the area actually trapped. This requires us to return to a question we had hoped to avoid: how to delineate the effective trapping area. Having fitted a spatial detection model to the data we can estimate this retrospectively. In our case the model indicated a buffer ('inferred strip width') of 450–1400 m about the traps (Efford 2004b). Home-range movements ensure that the traps effectively sample ferrets living within this buffer. The buffered area included much more than 50% of each study area, and we therefore feel confident that the trapped sample was representative.

2. We encountered problems with occasional dispersal movements during a trapping session. It is unclear whether these were common enough to degrade the estimates. A simple solution would be to undertake ferret monitoring at times of year when little dispersal is expected.

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