DISCUSSION

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Introduction

My interest in capture-recapture models has been primarily in traditional applications in wildlife and fisheries. I have seen data from species as different as mice and alligators! My experience has now been broadened by these two papers to include capture-recapture of federal employees and criminals in Washington, D.C. (presumably disjoint sets!).

Before I discuss the specifics of the two papers I thought it would be helpful to give a brief review of the different capture-recapture models. Some of the audience may not be familiar with the wide range of models available. A useful general reference is Seber (1982).

Capture-Recapture Models

Capture-recapture models fall naturally into two classes of closed and open models. Closed models are typically used in short term studies where it may be reasonable to assume that the population is constant (i.e., closed to births, deaths and migration). Open models are often needed in longer studies where birth and death parameters become very important.

For closed populations there is a series of models of increasing complexity which allow for unequal catchability of individuals due to:

(i) Heterogeneity: The probability of capture in any sample is a property of the individual and may vary over the population. That is, individuals may vary in capture probability according to age, sex and many other factors;

(ii) Trap Response: The probability of capture in any sample depends on the individual's prior history of capture;

or(iii) Time: The probability of capture of an individual may change over time for a variety of reasons.

The following table gives a set of eight mutually exclusive closed population models based on the above classification of unequal catchability (see Otis et al. (1978)).

CLOSED POPULATION MODELS

Model	Unequal Catchability due to		
	Trap Response	Heterogeneity	Time
M_o			
M_b	X		
M_h		X	
M_{bh}	X	X	
M_t			X
M_{tb}^*	X		X
M_{th}^*		X	X
M_{tbh}^*	X	X	X

*These three models do not have Population Size Estimators available.

For open populations the basic model is called the Jolly-Seber model (Seber (1982, p.196)). This model makes the crucial assumptions that all individuals alive at a particular sampling time have an equal probability of capture and an equal probability of survival until the next sampling time. The parameters of interest are the population sizes at each time (N_i), the survival probabilities (ϕ_i) and the birth numbers (B_i). The estimators take a simple intuitive form (Seber (1982; p. 200)).

Recently (Pollock (1982)) I suggested a capture-recapture design for long term studies which allows use of both open and closed population models in data analysis. The advantage of this design is that population size estimation uses closed population models which are robust to unequal catchability. I believe it is possible that this design will become widely used in a variety of applications.

Specific Comments

The paper by Fishbach et al. uses closed population models to estimate the numbers of workers in an agency or plant where accurate files on workers' appointments are not kept. Current employees are asked to create lists of all the employees that they can recall working in the plant. A list is analogous to a capture occasion and a name appearing on more than one list is analogous to a recapture.

In this unusual application "capture" probabilities are extremely high so that there is little problem with precision of the estimates. Therefore it becomes important to concentrate on methods of sampling to satisfy model assumptions. There is likely to be some heterogeneity of capture probabilities for individuals over the different lists. However, this is unlikely to cause any negative bias on the estimates due to the very high capture probabilities. The crucial assumption as I see it relates to memory bias problems. Evidence is presented in this paper that "bogus" employees showed up on some of the lists. Common sense dictates that only employees likely to have good recall should be used. As the authors suggest, plants should be divided into divisions and list compilers should only compile lists for their own division employees.

The paper by Greene uses closed and open models to estimate the size of the male criminal population for Washington, D.C. using arrest records over the two-year period of 1974-75. I believe that the results of these analyses could be very important to criminologists but I believe the author could pursue his analyses further.

I suggest the author use the Jolly-Seber model estimates for all his data and calculate standard errors. I also suggest he consider plotting survival rates, population sizes and birth numbers estimated from the Jolly-Seber model against age to see if there are important trends. If trends are suggested I would carry out weighted regression analyses.

I also suggest the author consider using the robust design (Pollock (1982)) for his data. It would be very interesting to compare the estimates of population sizes and birth numbers for the robust method and the Jolly-Seber method.

References

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Pollock, K. H. (1982). A capture-recapture design robust to unequal probability of capture. Journal of Wildlife Management 46, 752-757.

Seber, G. A. F. (1982). The Estimation of Animal Abundance and Related Parameters. Macmillan: New York, 654 pp.