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A MODEL TO OPTTMTZE TRAP SYSTEMS USED FOR SMALL MAMMAL (RODENTIA, INSECTIVORA) DENSITY ESTIMATES

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ABSTRACT - The environment found in the upper and lower Padane Plain and the adjoining hills isn't very homogeneous. In fact it is impossible to find biotopes extended enough to satisfy the necessary criteria for density estimate of small mammals based on the Removal method. This limitation has been partially overcome by adopting a reduced grid. counting **39** traps whose spacing depends on the studied species.
Aim of this work was to verify - and eventually measure - the efficiency of a sampling method based on a "reduced" number of catch points. The efficiency of I8 trapping cycles. realized from 1991 to 1993. was evaluated as percent bias. For each of the trapping cycles, 100 computer simulations were performed, so obtaining a Monte-Carlo estimate of bias in density values. Then later. the efficiency of different trap arrangements was examined by varying the criteria. The numbers of traps ranged from 9 to 49. with trap spacing varying from 5 to 15 m and a trapping period duration from 5 to 9 nights. In this way an optimal grid system was found both for dimensions and time duration. The simulation processes involved, as a whole. 1511 different grid types. for 11347 virtual trapping cycles. Our results indicate that density estimates based on "reduced" grids are affected by an average - 16% bias, that is an underestimate, and that an optimally sized grid must consist of 6x6 traps square, with about X.7 m spacing. and bc in operation for 7 nights.

Key words: Removal method, Monte-Carlo simulations, Small mammals, Population density.

INTRODUCTION

In autoecological studies on small Mammals the use of a reliable instrument to obtain population density cstiinates as close as possible to the real values is of prime importance. However, the "trapping effort" has to be kept as low as possible. In other words there arc constraints depending on the number of traps, the time spent in the field, the impact on the trapped population etc..
Commonly used methods are based either on techniques that do not involve killing the caught animal (*e.g.* Capture-Mark-Recapture methods), or **on** the physical removal of the caught individual (*e.g.* Removal Method, Standard Minimum Method).
In this work we considered only a "reduced version" of the Standard Minimum Method (SMM: Grodzinski *et al.,* 1966). The "classical" protocol considered 256 trapping points, arranged in a square grid, formed by one or more traps per point. Density estimates are then extrapolated by means of the Regression Method (R M. Hayne, 1949). The principal limitation of this method is that the grid must be placed in an area "which is reasonably uniform in vegetation and physiography". according to the definition

given in McLulich (1951). Unfortunately, in many cases it is really difficult to satisfy this rule. In fact. identifying biotopes which are spread out enough to allow a 256 traps grid and which satisfy homogeneity constraints is not easy. Attempts to validate a reduced-size trapping system were carried out in the early 70's, for instance by Pelikan (1971) and Myllymäki *et al.* (1971). These works showed how "small quadrats" were possible only for certain species. A "general purpose" trapping system based on small grids was not found. The trend among researchers has been to use reduced-size grids, like the one proposed by Montgomery (1981), or the one outlined by Cantini and Cameron (1989).

Shortening grid dimensions implies a reduction of the total catch probability, which is related to the trapping effort. i.e. " the number of traps used per the number of nights". In brief, the sample obtained might be less representative than the one obtained with the original SMM 256-trap grid.

So, the aspects which need verification in such "reduced" trapping systems are thus the reliability of the density estimates obtained and the overall applicability of time and space reduced trap systems.

These tasks were carried out by use of computer simulations. performed after a careful analysis of the trapping process on which a model was formulated. The algorithmical model was based on a representation of the events (Robertson *et al.*, 1991; Farmer and Kycroft. 1991).

The 49-traps reduced system reliability has been evaluated by 18 simulations based on real data collected in the field. The efficiency of the trap system was evaluated in terms of percent relative bias of the estimate, as proposed by Manly (1970). An exhaustive description of this method as an efficiency estimator can be found in Smith *et al.* (1971).

Those results allowed us to try and estimate the efficiency of different-sized grids, in order to find an optimal grid size. For this purpose. we considered grid geometries which ranged from 3 to 7 traps per side. including rectangular arrangements. and trap spacing from 5 to 15 m. The time of activation of the grid varied from 5 to 9 nights.

Material and methods

Let us define C_g as the number of catches for each day (*daily catches*), and C_c as the number of individuals caught up to the preceding day (*cumulative catches*). **N** individuals will be present inside the grid area. During each of the **d** nights of trapping. $C_{g(d)}$ individuals will be caught. If we assume that the probability of catching **an** individual does not vary and that of migratory phenomena are absent. for each consecutive night a decreasing number of individuals will be caught. That is to say, $C_{g(d+1)}$ will decrease when **d** increases. until it will reach a zero **value**. the day **D**, when all individual have been removed.

The cumulative catches calculated for a day **i** is:

$$C_{c(i)} = \sum_{d=0}^{d=i-1} Cg_{(i)} \qquad [1]$$

The above hypotheses means that we will have an increasing trend for C_c and a decreasing one for C_g. Furthermore. if we consider the trapping effort which is related to the number of traps used and to the probability of capture for an individual as being constants. then the removal rate of the individuals from the grid area will also be constant. We may hypothesize then that C_c and C_g are in linear dependence. with C_c as the independent variable. A model of this is expressed by the equation

$$Cg_{(i)} = a + b\, Cc_{(i)} \quad [2].$$

where **a** stands fur the number of individuals caught on the first night of trapping, and **b** is the removal rate.

If C_g values have a decreasing trend. a linear regression will give estimates for **a** and **b** values. It is clear that, given the model's hypotheses. the **b** value must he less than zero. The intersection between the regression line and the C_c axis. that is the "zero caught" point, will give an estimate of the number of individuals **N**, present in the area, that is

$$N_e = -\frac{b}{a} \quad [b < 0] \qquad [3].$$

The standard error of N_e can be evaluated by using the standard parameters estimate techniques for a type II regression (Sokal and Rohlf. 1981).

In order to obtain a density estimate. it is necessary to correct the grid surface area A_{grid} by adding a border: for instance using the Arbitrary Border Zone Method (Smith *et al.*, 1971). whereby it is assumed that **a** border width is equal to half the trap spacing. This will yield

$$A_{tot} = A_{grid} + 4l\frac{i}{2} + \pi + \left(\frac{i}{2}\right) \qquad [4],$$

in which I is the distance between two traps (trap spacing).

It is then possible to obtain a density estimate. not considering the fact that different species have been caught.

The model relative to the dynamics of a trapping cycle has heen translated into a computer program; the flow-chart of this program is represented in Fig. 1. System parameters arc:

- avcrage population density ± SE;
- avcrage home range radius ± SE:
- grid side lengths, expressed as number of traps;

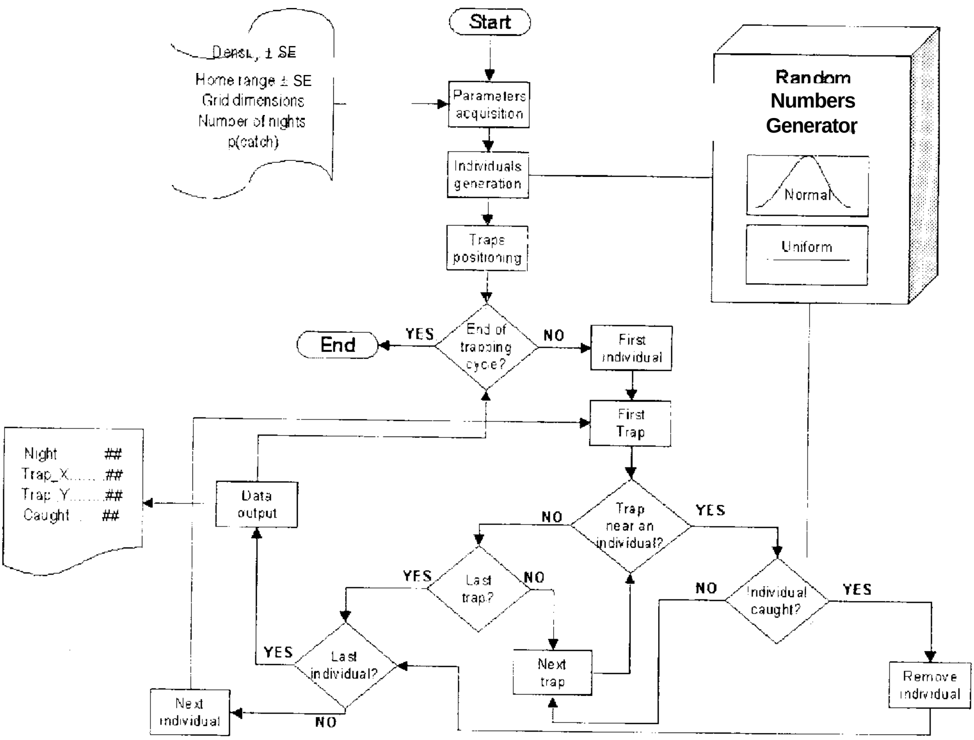

Figure 1 - Flow-chart of the model used in the simulation process.

trap spacing in meters;
average probability of being caught for an individual (from 1 to 100).

The program may be executed in batch mode, in order to generate large quantities of data.
Furthermore, due to the quantity of data produced. the program itself performs all the calculations needed to obtain as a result the bias estimate.
Starting from an average population density, a normally distributed density can be randomly generated by considering an area 10 times greater than the grid area, to obtain an homogeneous distribution of the "borderers", that is the individuals immediately outside the grid area. A position in space **is** then assigned to each individual, by computing a pair of Cartesian coordinates randomly generated with an uniform distribution. In the same way a home range radius can be assigned. In this case radii are generated with a normal distribution.
For a number of nights which is equal to the specified value the program "catches" individuals by checking for each of them the presence of at least one trap within the home-range limit. If this is true, then the probability of being caught has to be evaluated. If the generated value is under the imposed average probability of being caught, then that animal is "caught" and "removed". The trap, for that "night" won't catch any more.
Those partial results are then used for "Regression Method" calculations. and to yield a bias estimate

$$B = -\left[\frac{N - N_e}{N} \bullet 100\right] \quad [5],$$

where **N** is the density value imposed on the program, and $\mathbf{N_e}$ is estimated by the Regression Method. Negative values of **B** indicate an underestimate, and positive values an overestimate. By repeating a single simulation 100 times an average bias estimate can be obtained using Monte-Carlo techniques.

RESULTS

A first series of simulations, performed using data derived from field, gave us an estimate of the biases that affect densities obtained by reduced SMM grids. The results can be seen in Table 1. The average bias is a 16.01% underestimate of the "true" population density.
A second series of simulations regarding the dimensions of the grid (width, length, trap spacing and number of nights) produced, on

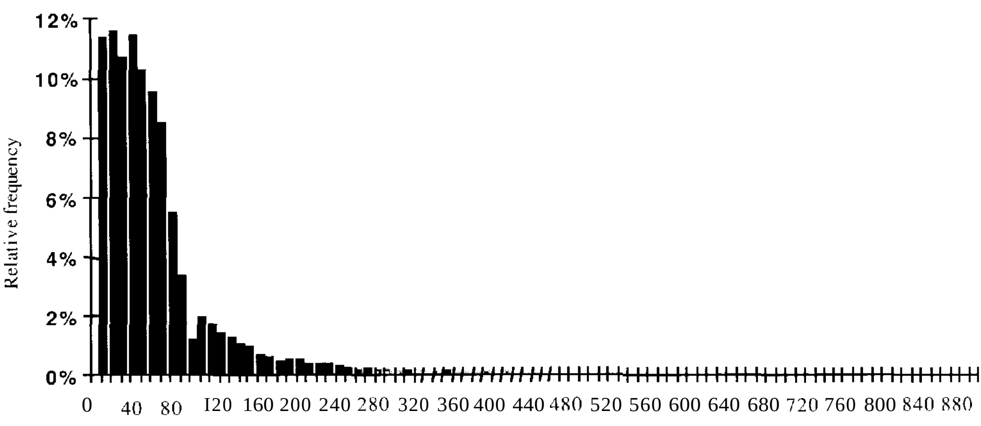

Figure 2 - Frequency distribution of the biases measured on different kinds of grids. Abscissas shows **absolute value** of bias. Notice that there are cases in which estimated density was even eight times higher than real density.

Table 1 - Results of the first series of simulations. Blackened rows indicate failed simulations, that gave no density estimates due to the low value of density imposed to the program. The "bias" column indicates the average bias on 100 simulated trapping cycles.

Simulation	Expected Density	Density estimate	**Bias**
1	323.01	533.20	65.07%
2			
3	51,80	40.06	-22,67%
4	17,68	4,37	-75,28%
5	19,28	11,50	-40,37%
6	23,81	12,79	-46,27%
7	85,70	64,79	-24,39%
8			
9	102,84	76,18	-25.92%
10	87.60	139.73	59.5 1%
11			
12	20.00	13,14	-34,29%
13	176.48	135.25	-23.36%
14			
15	177,56	169,94	-4,29%
16	57 70	60,92	5.59%
17	93,31	54,67	-41,41%
18			
Avg	95,14	101.27	- 16.01%
Std	83,81	134.87	38,38%
Var	7023.96	18189,43	14,73%
Max	323.01	533,20	65,07%
Min	17.68	4,37	-75,28%
SEM	8,38	13.49	3,84%

a total of 11.347 simulation cycles, the frequency distribution of bias measures reported in Fig. 2, where the bias is expressed as an absolute value. Data in Table 2a presents relative and cumulative frequency of each bias class.

A correlation test was performed on this data, to check for the existence of correlations among grid dimensional parameters. Results reported in Table 2b show that such a correlation does not exist.

Unfortunately it wasn't possible to coerce these results into a multivariate model of the type

$$\text{Bias} = \alpha + \beta \cdot \text{width} + \gamma \cdot \text{length} + \delta \cdot \text{spacing} + \varepsilon \cdot \text{nigth} \quad [6],$$

in order to minimize the bias and find an optimal grid size with a minimum bias. Thus, optimal dimensions were found averaging out the grid types which yielded an absolute value bias not greater than 10%. These results are presented in Table 3.

CONCLUSIONS

It is possible to conclude that. theoretically, grids of traps of utilized dimensions operated according to the SMM protocol are useful for density estimates of small mammals populations living in highly fragmented habitats. In addition, the "reduced SMM' seems to be reliable and more practical than the "classical SMM". In fact, the wider the grid is, the clearer the density estimate obtained will be, but a 200m sided grid is rarely possible. No doubt, it is better to use a less extended grid design, that will be also less precise but useful in a wide range of habitat situations. This is in agreement with what emerged from the tests performed by Pelikan (1971), who highlighted how small

Table 2 - Part a: relative and cumulative frequences of each bias class. Part b: correlation matrix for grid parameters (length, width. spacing. nights) and bias.

b	Relative Frequencies	Cumulative Frequcncica
0-10%	11,3%	11,3%
11-20%	11.4%	22.7%
21-30%	10,6%	33.1%
31-40%	11.4%	44.7%
41-50%	10,1%	54.8%
51-60%	9,4%	64,2%
61-70%	8,4%	72.6%
71-80%	5 5%	78,1Q
81-90%	3.3%	81,4%
91-100%	1.2%	82,6%

sider in comparison that when censusing highly contactable species, like Ibex or Chamois, the real population density can be underestimated in a range of 10-20% (Tosi and Scherini, 1991).

The possibility of minimizing biases and errors is also important. However it was not possible to find a connection between bias and grid parameters. This suggests that biases do not depend on grid structure but are correlated to other parameters, for instance to the weather and the nature of the trapping site. The proposed "optimal" grid is slightly smaller than the one normally used but seems it still seem efficient. Another important factor could be the nature of a trapping point. usually made by only a single trap. The use of at least two traps should eliminate some "trap competition" effects that would lead to mistakes and underestimates in the case of subordinate species (*e.g.* the case of *Clethrionomys glareolus* and *Apodemus sylvaticus*).

	Width	Spacing	Nights	Expected density	Density estirnatr	Bias
Length	0.6**	—	—	—	—	—
Width		—	—	—	—	—
Spacing			0.07**	—	—	—
Nights				–	—	—
Expected density					0.8**	—
Density estimate						0.4**

** = (p>0.05)

grids (from 2x2 up to 12x12 traps) yielded similar density estimates, and suggested an 8x8 grid as being optimal. It is worth noting that small mammals population densities calculated for northern Italy arc far less than those presented by Pelikan for northern Europe where densities are higher so that even small grids give reliable results. Plus, a 16% underestimate for animals such as small mammals is quite a good result, if we con-

Table 3 - Average grid parameters, evaluated on grid designs yielding biases in the -10% to 10% range.

	Length (traps)	Width (traps)	Spacing (m)	Nights
Avg	5.7	4.7	8.7	6,7
s.d.	1,2	1,2	2.9	1,8
95QC.I.	0.07	0,07	0,16	0.10
SEM	0,03	0.04	0,08	0.05
N	11347	11347	11347	11347

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