A C T A T H E R I O L O G I C A

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Estimating the Density of Rodents by Means of Stained Food

[With 2 Tables & 1 Figs.]

In order to estimate density removal trappings of rodents were carried out four times. A 5.76 ha grid of snap traps spaced 15 m apart was laid out and a central square area 1.10 ha in extent was marked. Rodents were prebaited for three days, and after this period food stained with fuchsin was laid out in the centre for one hour. Than all bait was removed and the rodents caught for 5 consecutive days. It was shown that the number of rodents estimated by the regression method should be referred to an area, greater than the area on which trapping was carried out by the set of points lying at a distance from this area the size of which depends on the reciprocal relation between size of home range and size of the experimental area. A knowledge of this relation makes it possible to use small trapping areas for estimating density of rodent populations.

I. INTRODUCTION

Many of the methods used for assessing numbers of rodents give grounds for doubt as to the reliability of such assessment in relation to the size of the area in which density is to be investigated. Assuming that the capture method used makes it possible to catch and remove all rodents (whose home ranges overlap the study area to a different degree) from an experimental area there must be doubt as to whether the individuals caught there do not also include those which have entered the study area from outside its limits. The aim of shortening capture and removal time to the greatest possible degree is to avoid including individuals which have not »been in time« to enter the area from outside defined limits. This does not, however, solve the question of extension beyond the limits of a defined study area of the home ranges of individuals belonging to this area, and also the home ranges of individuals overlapping into the study area, but not contributing to the density of rodents within it. One way out of this situation is to set up large study areas (that is, large in relation to the size of the home range of the given rodent species), where the ratio of extent of this area to the periphery forming its boundary is more favourable than the ratio of this periphery with small study areas, and where the periphery consequently »intersects« theoretically fewer home ranges.

An example of this solution is formed by the capture and removal method (Hayne, 1949; Grodziński, Pucek & Ryszkowski, 1966), with a short capture period and extensive study area. The problem, however, remains insoluble as to whether this area is sufficiently large and in consequence, to what area the captured individuals should be related in order to assess density.

The purpose of the present study is to attempt to assess the density of rodents, taking into consideration the size of the home range and the study area.

II. CAPTURE METHOD AND CALCULATIONS

Central parts, 1 ha in size, were marked out within four standard areas 5.76 ha in extent (cf. Grodziński *et al.* 1966). After laying out bait for three days in the central squares to attract the rodents, the usual bait was removed and bait stained with basic fuchsin was put out for 1 hour (Adamczyk & Ryszkowski, 1968). This bait was next very carefully collected and removed, while bait was also removed from the other part of the area and snap traps set. Captures of rodents were continued for 5 days. The alimentary tract of the animals caught was dissected to find which of them had consumed stained food. The results obtained from four areas of this type were added and an analysis made, introducing the following symbols:

S_1 — size of area in which fuchsin was put out (64 traps set in a grid at 15 m intervals)
S_2 — size of whole area (256 traps arranged analogically to area S_1),
$N_t(S)$ — number of rodents caught on capture day t, on area S ($S=S_1$, S_2),
$N'(S)$ — number of rodents (assessed) the home ranges of which overlapped completely or partly on to area S ($S=S_1$, S_2),
$N''(S)$ — number of rodents (assessed) »forming« the density in area S ($S=S_1$, S_2),
p — probability of capture of a rodent during trapping,
v — degree to which the home range overlaps the study area,
$\bar{v}$ — average degree to which the home range overlaps the study area,
r — length of side of a square study area.

It was assumed for the purposes of this study that density is the number of rodents present in a unit of areas in time $\Delta_t \rightarrow 0$. Time Δ_t covers a period when the activity of rodents $\simeq 0$. During this period there are individuals in the study area, the home ranges of which lie completely within the study area, and also part of this group of individuals, the home ranges of which »interesect« the boundary line of the defined study area. Together with increase in time Δ_t an increasingly larger number of rodents is caught among those with home ranges overlapping the area in which traps are set. Thus relating this number of rodents to the size of the study area over-estimates density.

In order to assess the number of rodents *N″(S)* we estimated the average degree ($\bar{v}$) to which a home range of defined size overlaps the area containing traps. The product of the number of rodents with home ranges overlapping the experimental area for $\bar{v}$ was taken as an estimate of the number of rodents forming density in area *S*. Thus

$$N''(S) = \bar{v} \cdot N'(S). \tag{1}$$

The average degree to which the home range overlaps — $\bar{v}$ is the arithmetical mean of indices *v* of degree to which the home range overlaps the area containing traps. The ratio of number of traps within the home range, coming within the study area, to all traps present within the home range, was taken as estimation of index *v* (for each rodent). The arithmetical mean of indices *v* for all rodents whose home ranges extend into the study area, is equal to the product of index *v* of defined size multiplied by the numbers of rodents with such an index. These numbers form the ratio of extent of the area in which there are centres of the home ranges of rodents with a given index *v*, to the total area, which includes the centres of all home ranges extending completely or partly into the experimental area.

The second factor of the right side of equation (1) was assessed by accepting the geometric distribution for capture day *t*. Assessment was made by means of the method described in studies by J a n i o n, R y s z k o w s k i & W i e r z b o w s k a, 1968; W i e r z b o w s k a, 1970. Therefore estimte *N′(S)* for area *S* is:

$$N'(S) = \frac{\sum_{t=1}^{5} N_t(S)}{1-g^5}, \quad \text{where } g = 1 - p \tag{2}$$

When estimating the number of rodents whose home ranges overlap the area with traps [$N'(S_1)$] the fact that traps placed round area S_1 catch rodents whose home ranges overlap S_1 was taken into consideration. Therefore the number of these rodents which did not consume fuchsin during the time it was available and whose home ranges overlapped area S_1, cannot be estimated by means of formula (2), in which $S=S_1$. The number of these rodents was estimated by accepting that the proportion of rodents which did not consume fuchsin, but were caught on area S_1, to all rodents without fuchsin, whose home ranges overplapped the experimental area (assessed here) is the same as the corresponding proportion for rodents which ate fuchsin. The number of rodents which ate fuchsin, and whose home ranges either completely or partly overlapped area S_1, were estimated from formula (2). The sum total of the

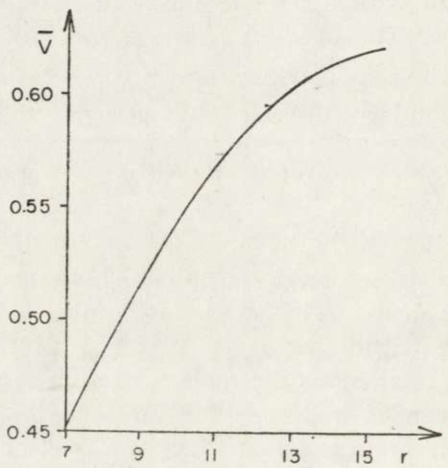

Fig. 1. Dependence of average degree of overlapping of the home range ($\bar{v}$) on the lenght of side of square experimental area, measured in 15 m units (r). Curve is based on actual data for bank vole, *Clethrionomys glareolus*.

above estimates gave the number of rodents whose home ranges overlapped area S_1. $N'(S_2)$ was estimated by means of formula (2) for data from area S_2, round which there were no traps, and where there was therefore no possibility of catching rodents outside area S_2.

III. RESULTS

When estimating the density of *Clethrionomys glareolus* (Schreber, 1780) analysed in this study it was accepted, on the basis of the results of the study by Andrzejewski & Wierzbowska (1969) that the size of the home range of the species analysed covers an area of 13 traps, which is equivalent for 925 m² (the area of effect of the trap was taken as 225 m^2). In addition it was assumed that the home range is circular, and that the rodent moves about it at random. With these assumptions we estimated the average degree of overlapping of the home range for squares with side lengths of: 105 m (area S_1), 135 m, 165 m, 195 m, 225 m (area S_2). The results obtained are given in Fig. 1.

The model described above was verified on the basis of results obtained from capture of rodents from area S_1 and S_2. Basic empirical data are given in Table 1.

It can be seen from Fig. 1 that the average degree of overlapping of the home range on to the experimental area increases together with increase in this area, with an established size of the home range, for

Table 1

Results of capturing rodents by the Standard Minimum method.

t	N_t (S) S_1		S_2	
	fuchsin	no fuchsin	fuchsin	no fuchsin
1	26	20	55	129
2	5	3	7	33
3	4	7	5	21
4	2	1	5	9
5	2	0	2	3
$\sum_{t=1}^{5} N_t(S)$	39	31	74	195

Table 2

Results of estimating density of rodents.

Food	With fuchsin+without fuchsin	
S	S_1	S_2
p	0.57	0.62
N' (S)	136	271
v	0.45	0.64
N'' (S)	61	173

area S_1, v=0.45, for area S_2, v=0.64. It is also clear from Table 2 that the probability of a rodent's capture on area S_2 during a capture day is greater than the analogical probability for area S_1. Inequality of this type is connected with the greater average degree of overlapping of the home range on area S_1 than S_2, with chances of a rodent's being caught in a trap uniform for both areas. The average degree of overlapping of a home range on to area S_1 is 0.45, and on to area S_2—0.64.

The data in Table 2 further show that among the 271 rodents assessed, with home ranges completely or partly overlapping area S_2, 173 rodents are considered as forming density on area S_2 (5.0625 ha). There are 0.77 rodents per unit of 225 m^2, and thus 271 rodents estimated for area S_2 form the density on an area of 352.45 square units (unit — 225 m^2) and thus on an area greater than area S_2 by the number of points at distance of 28.2 m in relation to area S_2.

It is clear from the above discussion that there are 34 rodents per hectare. These calculations apply to the results totalled for 4 areas and therefore the density on an area of 1 ha is 9 individuals. Analogical argumentation as for area S_2 were made for area S_2, where a density of 14 rodents per hectare was obtained.

The differences found may result from accepting home range size from the study by Andrzejewski & Wierzbowska (1966), which may be under-estimated for the data analysed in this study, which were collected during the autumn.

IV. DISCUSSION

It has been shown in this study that the accuracy with which density of rodents is assessed depends on the interrelation between the size of the individual home range and the size of the experimental area. Referring the number of rodents of a given species (with a defined home range size), assessed by the regression method, to the experimental area is burdened by error, the greater, the larger the area. Analogically, for an experimental area of defined size, the smaller the individual home range, the smaller the error in estimating density. Attention has been drawn to this type of relation between the size of the experimental area for which density is estimated, and the size of the home range (without giving its size, but by means of distinguishing species) by Pelikan in his studies (1970, 1971). It can be seen that the size of the home range has been taken into consideration to some extent in Ryszkowski's proposal for estimating density (1970). The number of rodents assessed by means of the regression method is referred to the experimental area in which the rodents were caught, extended by the set of points a units distant from this area. Value a was obtained by solving the appropriate equation. This value contains the relation »size of home range and size of experimental area«. It depends, however, on the size of the two areas taken into consideration when calculating it. Thus, for a species of a defined home range size estimation of density depends on the choice of these two areas. The method proposed by Ryszkowski (1970) has certain analogies with that proposed earlier by Hansson (1969). The calculating principle is similar, except that addition is made to the smaller of the two areas taken into consideration and considered as uniform from the point of view of Pelikan's method (1970), of the set of points at a distance from it amounting to half the distance between traps, and distance a related to the larger area is estimated from the appropriate proportion.

The method presented in our study points to the type of dependence of density estimation on the reciprocal relation between the size of the home range and the size of the experimental area. Further correction of the method should proceed in this direction, that is, taking this type of relation into consideration.

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OCENA ZAGĘSZCZENIA GRYZONI PRZY POMOCY BARWIONEGO POKARMU

Streszczenie

Dla oceny zagęszczenia przeprowadzono czterokrotnie odłów gryzoni z powierzchni kwadratowej, o wielkości 5,0625 ha, przy rozstawieniu pułapek co 15 m., oraz na centralnej powierzchni kwadratowej wielkości 1,1025 ha. Po trzech dniach przynęcania gryzoni za pomocą zwykłej przynęty w centrum, wyłożono na jedną godzinę pokarm barwiony fuksynę po czym przynęty usunięto i wyławiano gryzonie w pułapki zabijające, przez 5 kolejnych dni. Wykazano, że liczba gryzoni oceniana metodą regresji winna być odnoszona do obszaru większego od powierzchni odławianej, o zbiór punktów odległych od tej powierzchni o wielkość zależną od wzajemnej relacji między wielkością areału a wielkością powierzchni eksperymentalnej. Znajomość tej relacji daje możliwość stosowania małych powierzchni odłowu dla oceny zagęszczenia.