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

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Trappability of Rodents Depending on Population Density

[With 2 Figs. & 5 Tables]

When estimating the trappability of rodents in a study area their trap activity was taken into consideration. This activity was expressed by the ratio of the distance between traps to the time interval between these captures. Correlation of this index with the rodents' density showed that the distance traversed is not subject to variation with an increase in the number of individuals (with a constant number of set traps) whereas the time interval between captures increases. Probability of capture, which is the function of density and size of the home range, therefore decreases. An equation is given which expresses how many traps are required in relation to the number of rodents in order to obtain the shortest possible time of waiting for captures.

I. INTRODUCTION

In order to estimate the density of rodents in a study area during a given interval of time one of the essential and basic elements which must be ascertained is the number of rodents caught. The number of individuals trapped decides upon how we estimate their numerousness in relation to the actual number of individuals present in the study area. It is frequently considered, however, that assessment of the number of rodents from captures in traps is more a measure of these rodents' activity (Dehnel & Borowski, 1952; Turček, 1953) than of their density or, as Heydeman (1955) puts it, their »density of activity«. If we agree with these views we can accept that there is activity of rodents, treated in a wide sense, *i.e.* their active movements over the area. By setting up traps in this area we create the opportunity for the rodents to encounter the traps and be caught in them, and thus in connection with activity we create the possibility of their being trapped.

The use of different removal capture methods — number of traps in relation to the size of the area, density of their arrangement, length of time for which they are kept open, different baits etc, is aimed at increasing the probability of the rodents' being caught (p) and in consequence the probability of a rodent's being caught (P_T) during the period T for which we are assessing population density. There is, however, always a doubt as to whether every individual of those present in the area does in fact succeed in being caught during period T, and thus whether probability P_T will be equal to unity and, consequently whether the assessed numerousness is a measure of the absolute number of individuals in the study area.

The *CMR* method and use of a calendar of captures (*CC*) (Petrusewicz & Andrzejewski, 1962) removes this objection to a certain extent by increasing, by means of an appropriately long period of studies, the possibility of the rodents' reaching the trap. On the other hand considerable prolongation of trapping time causes yet another difficulty, since it creates the possibility of individuals being caught not solely from the area, in the density of which we are interested. The situation is not changed by the fact that a certain part of the rodents which are not very active, or trap shy, or the home range of which does not correspond with the trap grid, will fail to be caught. The density of individuals in relation to the number of traps set up is also a very important factor here. This ratio may exert a decisive influence on the number of captures of rodents (Janion, 1968). This also applies to invertebrates (Kaczmarek, 1963). The ratio of number of captures to the number of rodents estimated from the calendar of captures will be a measure of activity (capture in traps) of the rodents in relation to density (numerousness). Petrusewicz & Andrzejewski (1962) define this as real trappability. If we make use of data from the calendar of captures, such as the spatial distance between the various captures in traps and the time in which these trappings took place, then we can accept the ratio of these values (distance to time) as the trap activity of the rodents at the appropriate density. It is possible to find a relation between probability of capture (p) and population density (N), by means of analysing the correlation of the activity index or its factors (distance in time and space between successive trappings) with density N.

The activity index presented thus depends on the size of the home range (which is the function of the average interval between successive captures) and the probability of capture p. By finding the relation between this index and density it is possible further to indicate the type of relation of capture probability p to population density and also to the size of the home range, which is also the function of density.

In addition to the index of the dependence of capture probability on density, using the activity index, the functional dependence of capture probability on density and the size of the home range is also given in this study, accepting certain premises in respect of the way in which the rodents move about the area. The accepted model was checked for empirical data.

II. METHODS AND CALCULATIONS

The way in which the model presented above operates was checked on the basis of data obtained from the following experiment. Thirty traps were arranged at 1 m intervals in an enclosure 86 m² in area, designed to prevent the rodents escaping. Marked rodents, *Clethrionomys glareolus* (Schreber, 1780) were released into the enclosure in groups of 5 individuals every 4 days, so that during the 24 days of the experiment a total of 30 individuals was obtained, *i.e.* a number corresponding

Table 1.

Values of average intervals between successive captures.
i — number of period of time including successive introduction;
j — number of period of time during which given group of rodents was relased;
$N_i = \sum_{j=1}^{i} N_{i,j}$ — number of rodents living during period i;
$N_{i,j}$ — number of rodents living during period i, relased during period j.

j \ i	1	2	3	4	5	6
N_i	5	10	15	20	25	30
1	2.15	2.68	1.94	2.66	1.52	2.84
2		1.59	1.00	1.99	2.45	1.99
3			1.60	0.84	2.20	3.33
4				2.34	0.98	3.57
5					2 64	1.67
6						2.41

Table 2.

Values of average intervals between successive captures and their standard errors, for rodents living in successive periods of introduction.
i; j — for explanation of symbols see Table 1;
$\bar{S}_i$ — mean interval between successive captures for rodents living in period i;
$\delta_{\bar{S}_i}$ — standard deviation (from sample) of average interval $\bar{S}_i$.

i	1	2	3	4	5	6
N_i	5	10	15	20	25	30
$\bar{S}_i$	2.15	1.79	1.37	2.20	2.35	2.10
$\delta\bar{S}_i$	0.29	0.28	0.25	0.18	0.23	0.23

to the number of traps. Trapping was carried out twice daily. An experiment of this type was carried out twice, once in July and once in August. As analogical results were obtained they were combined and calculated jointly.

Values $\bar{s}$ and $\bar{t}$ were calculated in order to examine the dependence of the activity index $V = \frac{\bar{t}}{\bar{s}}$ (where $\bar{s}$ = average sector of distance between successive captures of rodents, $\bar{t}$ — average interval between successive captures) on density. The results of calculations of the average distance between captures are given in Table 1. The absence of significant difference between the distance obtained for rodents with a different length of stay in the enclosure made it possible to present the value of this distance at a defined density for all the groups jointly (Table 2). Accepting the significance level of $\alpha = 0.05$ calculation was made of the confidence intervals for these means (Fig. 1).

The time interval between captures is equal to the converse of trapping probability p. This probability was estimated on the basis of the distribution of number of captures with a defined density of rodents, in the following way.

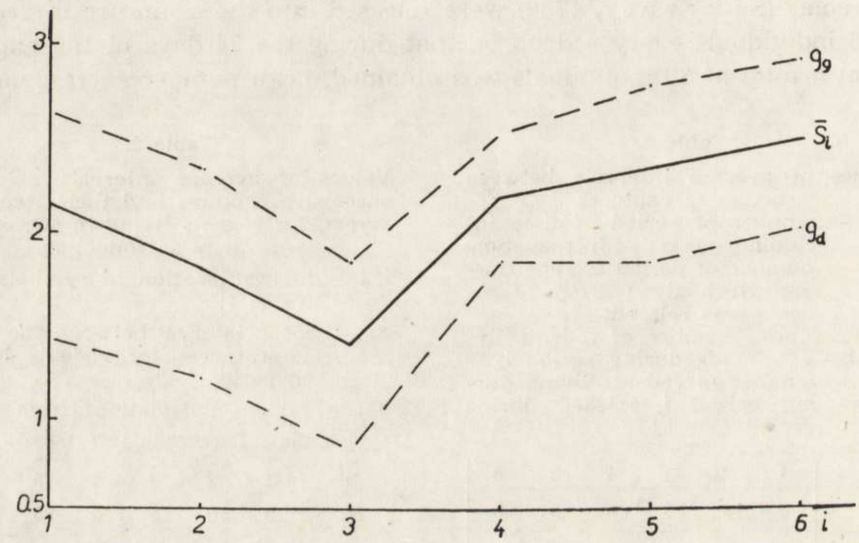

Fig. 1. Confidence intervals for average interval between successive captures (confidence index 0.95).
S_i — average (sample) interval between successive captures for rodents living during period i; g_g, g_d — upper and lower limits of confidence intervals for average interval between successive captures.

X_{ij} was used to indicate the number of captures of rodents which lived during a period including i successive introduction ($i = 1, 2,..., 6$), and were released during period j ($j = 1, 2,..., i$). N_i indicates the number of rodents living during period i.

Since during period i ($i = 1, 2, ..., 6$) each rodent living in the enclosure could have been caught 8 times, estimation of probability p is

$$\hat{p}_i = \frac{\sum_{j=1}^{i} x_{ij}}{8 \cdot N_i}$$

where x_{ij} is the value of the variable X_{ij} from the sample (Table 3). The activity index was calculated on the basis of values S and p obtained above (Table 4).

The following model was considered for exact definition of the functional relation between probability of trapping and population density and size of home range.

Let us assume that rodents move at random over their home range. The first rodent to be trapped is thus the one which first enters the trap. If the trap is blocked it is impossible for other rodents to be caught.

Table 3.

Estimation of probability of capture as population density increases.
$i; N_i$ — for explanation of symbols see Table 1;
$\hat{P}_i$ — estimator of capture probability P_i;
$\hat{g}i = 1 - \hat{p}_i$.

i	1	2	3	4	5	6
N_i	5	10	15	20	25	30
$\hat{p}_i$	0.50	0.33	0.26	0.28	0.20	0.18
$\hat{g}_i$	0.50	0.67	0.74	0.72	0.80	0.82

Table 4.

Dependence of activity index on population density.
$i; N_i$ — for explanation of symbols see Table 1; V — value of activity index.

i	1	2	3	4	5	6
N_i	5	10	15	20	25	30
V	1.08	0.59	0.36	0.62	0.47	0.38

Bearing the above assumptions in mind we find that probability of capture of a rodent on the trapping day is

$$p = \frac{r}{r + N - 1} \tag{1}$$

where:
r — number of traps present in the rodent's home range (this value was taken as a measure of the range), N — number of rodents moving about a common range of value r of the traps contained in it.

The probability of catching rodents in the trap on the day of trapping is thus in direct reverse proportion to density and depends on the size of the individual's home range. This relation was checked by means of empirical data. Estimates of parameter r were made by means of the method descibed in previous studies (Adamczyk, Janion, Ryszkowski & Wierzbowska, 1966; Andrzejewski & Wierzbowska, 1970; Wierzbowska & Chełkowska, 1970). As the number of rodents was less than that necessary to assess home range with the given densities, parameter r was assessed for the whole study period. The value of estimator $\hat{r}$ of parameter r obtained was 10 traps. Next accepting for the sake of simplicity the maximum overlapping of home ranges, we obtain an estimated probability of capture p ($\tilde{p}$). (Table 5).

III. RESULTS

Analysis of the dependence of activity index on population density showed that this index decreases with an increase in density (Table 4). This is a result of decreasing probability of capture p depending on population density (the mean time interval between successive captures increases) and absence of change in the average distance between successive captures (S) depending on population density (Table 3).

Table 5.

Estimation of probability of capture depending on population density (based on model).

$i; N_i$ — for explanation of symbols see Table 1;

$\tilde{p}$ — value of estimator fo capture probability based on relation (1);

$\tilde{g} = 1 - \tilde{p}$.

i	1	2	3	4	5	6
N_i	5	10	15	20	25	30
$\tilde{p}_i$	0.77	0.55	0.39	0.32	0.27	0.24
$\tilde{g}_i$	0.23	0.45	0.61.	0.68	0.73	0.76

Analysis of the dependence of probability of capture on density presented by means of equation (1) shows (Table 5) that this probability depends on density. The disparities obtained between probability estimate p and $\tilde{p}$ are due to the difference in the premises of the two models and to an insufficient number of samples. Probability of capture decreasses with increase in density (Table 3 and 5) when the home range remains unchanged. Thus, the more rodents there are in relation to the constant number of traps, the longer it will be necessary to wait to catch and remove a given percentage of rodents. The percentage of rodents which were trapped during T trapping units depends on the probability of capture p in the following way:

$$P1_T = (1 - g^T) \cdot 100$$

where: $g = 1 - p$, T — number of successive trapping.

Fig. 2 shows the relation between the consecutive day of removal captures and the percentage of rodents which will be trapped up to that day. Cases are given here in which from 5, 10..., 30 rodents move over an area equal to 10 traps, and thus when there are respectively 0.5, 1, 1.5,..., 3 rodents per trap in the area.

The results given in Fig. 2 show that the waiting time (measured by the number of removal captures) necessary to trap and remove 90% of the rodents increases with an increase in population density.

IV. DISCUSSION

Many factors contribute to probability of capture of rodents in traps and to the assessment of numerousness of these rodents. Generally speaking it may be considered that there are three basic factors which decide whether a rodent is captured or not. The first of these is the rodent's presence and penetration over the area, its activity; the second, entry into the trap or other device to catch the rodent, and the third, the

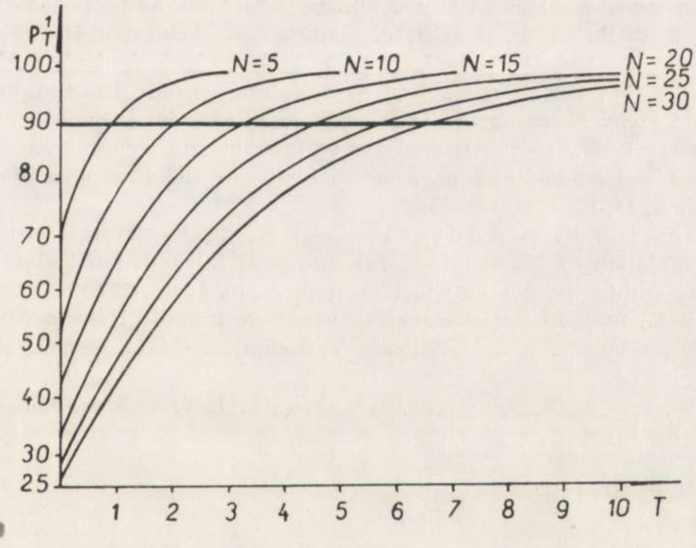

Fig. 2. Rate of removal trapping of rodents from experimental area. T — successive day of removal trapping; P'_T — percentage of rodents removed up to day T.

method which to a greater or lesser degree facilitates utilization of the first and second element, *i.e.* activity and possibility of entry into the trap. We can choose the method to be used in capturing rodents and consequently we have to do with a certain number of individuals, that is, those caught. We do not know much about the first factor *i.e.* the possibility of these individuals' reaching and entering the traps, and thus their activity in relation to the trap. The index of trap activity introduced in this study and the analysis made permitted of showing more or less clearly, that the number of traps in relation to the numerousness of rodents exercises an influence on capture of rodents. Thus, with given numerousness some of the individuals present in the study area may not be caught or taken into consideration in the total estimate of numbers.

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ŁOWNOŚĆ GRYZONI W ZALEŻNOŚCI OD ZAGĘSZCZENIA POPULACJI

Streszczenie

W ogrodzonym terenie, na którym eksponowano stałą liczbę pułapek, zbadano wpływ wzrostu zagęszczenia gryzoni (*N*) na prawdopodobieństwo złowienia (*p*). Badania przeprowadzano w ten sposób, że co cztery dni wpuszczano 5 osobników

Clethrionomys glareolus (Schreber, 1780) przy ciągle stałej liczbie eksponowanych pułapek (30). Dokonano 6-ciu wpuszczeń gryzoni, tak że w końcowej fazie doświadczenia uzyskano liczbę osobników odpowiadającą liczbie eksponowanych pułapek (30 i 30). Przyjęto, że prawdopodobieństwo złowienia (p) zależne jest od wielkości areału gryzonia wyrażonego liczbą punktów, które odwiedza (r), oraz od liczby gryzoni (N). Przy takim założeniu prawdopodobieństwo złowienia wynosi $\frac{r}{r + N - 1}$. Przy nie ulegającej zmianie liczbie pułapek a wzroście liczby osobników zmienia się albo liczba odwiedzanych pułapek (r) a więc funkcja tej liczby, średni odcinek między złowieniami ($\bar{s}$), albo średni czas ($\bar{t}$) dzielący kolejne złowienia. Stosunek tej drogi ($\bar{s}$) do czasu ($\bar{t}$) określono aktywnością gryzoni do pułapek. Stwierdzono, że w miarę wzrostu zagęszczenia nie ulega zmianom wielkość $\bar{s}$ (oraz r), natomiast zmienia się (wzrasta) czas oczekiwania ($\bar{t}$) na złowienie. Procent gryzoni, które złowią się w czasie T jednostek połowowych zależy od prawdopodobieństwa złowienia następująco:

$$P^1_T = P_T \cdot 100 = (1 - q^T) \cdot 100, \text{ gdzie } q = 1 - p$$

Wynika z tego, że im więcej jest gryzoni w stosunku do aktualnej liczby pułapek, tym dłużej trzeba czekać aby złowił się określony procent gryzoni, a więc liczba pułapek na powierzchni doświadczalnej powinna być odpowiednio duża w stosunku do liczby gryzoni.