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

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Krystyna ADAMCZYK & Lech RYSZKOWSKI

Estimation of the Density of a Rodent Population Using Stained Bait*)

[With 15 Tables]

It was found in laboratory investigations that traces of oats stained with basic fuchsin are retained for up to eight days in the alimentary tract of rodents. Using this finding studies were made, using the Standard-Minimum method, on the density of small rodents in 10 areas in forest biotopes. Oats stained with basic fuchsin were used as bait. Analysis was made of the two most numerous species, *Clethrionomys glareolus* (Schreber, 1780) and *Apodemus flavicollis* (Melchior, 1834), among which individuals containing fuchsin formed 80 and 72% respectively. No differences were found between individuals with and without fuchsin as regards age, weight and percentage of ♂♂ and ♀♀ containing fuchsin among the animals caught. Twice as many animals were caught on the border of the study areas than were caught inside them. Removal by capture ends on the third day in the interior part of the areas, and it is characterized by the highest value and constant rate in successive days. On the strength of this finding it was proposed to estimate density in habitats with even distribution of animals on the basis of captures of individuals in the interior part of study areas, converted to unit of area.

1. METHODS AND STUDY AREA

Captures of the rodents were made by the Standard-Minimum method (Grodziński, Pucek & Ryszkowski, 1966), which involves laying bait for five days, followed by captures of the rodents for five days. Captures were made on an area of 5.76 ha, marked by 16 rows and 16 lines perpendicular to them. The distance between rows and lines was 15 metres. The intersections of lines and rows formed 256 points at which bait was placed, then after five days snap traps, setting two traps on every point, were spread.

During the baiting period inspection was made daily of the consumption of bait, which was supplemented where necessary. The five-day baiting period was divided into two phases. In the first phase, which lasted two days, unstained oats was placed on the points, but during the second, three-day phase, husked oats dyed with basic fuchsin were used.

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The oats were stained with basic fuchsin in the following way: half a gramme of fuchsin was dissolved in 1 litre of hot water, then the husked oats were added to the solution, which was boiled and removed from the heat, and dried after one hour. The following experiment was made in order to check how long the fuchsin-stained oats are retained in the alimentary tract. White laboratory mice (*Mus musculus* L.) were fed on stained oats. After the animals had eaten they were transferred to other cages with unstained food. Every twenty-four hours two of the mice were killed and dissected, and the contents of the alimentary tract (stomach, caecum) were placed in water in Petri dishes. A search was made for traces of stained food using a binocular microscope. It was found that traces remain in the alimentary tract (especially in the caecum) for not less than eight days. This experiment was repeated, with the same result, using *Clethrionomys glareolus* (Schreber, 1780).

After keeping the rodents supplied with stained bait for three days, the uneaten remains were carefully removed from the area, and snap traps placed on the baiting points. A cotton wick fried in oil with slightly browned wheat flour was used as bait in the trap. The traps were inspected in the morning and evening. On the fourth day of captures traps were additionally placed in four lines (transects) forming an extension of the middle rows and lines. A pair of traps was placed in each transection at intervals of 15 m, for a distance of 150 m. Captures on the transects lasted 3 days, that is, one day longer than captures in the area.

Captures of the rodents were made in the forests near the Field Station of the Institute of Ecology at Dziekanów Leśny near Warsaw and in the Mikołajki area in the Mazurian region. Two series of captures were made in the Dziekanów area: (1) in an *Cladonio-Pinetum* association (this station will be given the symbol *CP* from now on), (2) in a forest consisting of the following associations: *Pino-Quercetum, Vaccinio myrtilli-Pinetum subass. molinietosum, Tilio-Carpinetum, Carici elongatae-Alnetum* (given the symbol *D* from now on).

In the Mikołajki area three series were carried out in a *Pino-Quercetum* association (*PQ* 1, 2, 3), five series in a *Vaccinio-myrtilli-Pinetum* association (*VP* 1, 2, 3, 4, 5).

In addition to captures by the Standard-Minimum method, special captures were made with the aim of estimating the range of penetration by small rodents (small cross captures). Nine points baited with oats stained with fuchsin, at 15 m intervals from each other, were arranged along each of two parallel lines 120 m long and 15 m apart. Bait was changed daily. The baiting period lasted 3 days, after which the bait was removed. Two rows of traps, each row 150 m long, were arranged perpendicularly to each line of bait. The distance between the rows was 30 m. Pairs of traps were arranged at 15 m intervals in each row. The rows were intersected by lines with bait in such a way that the left row intersected the lines at a distance of 45 m from their left end, and right row 45 m from the right end of the line. This arrangement of bait and traps formed the shape of a cross in the study habitat. This method will henceforward be termed the cross method and the captures, cross captures.

Eight series of small cross captures were carried out in the area of the Field Station at Dziekanów Leśny in a forest consisting of the following associations: *Pino-Quercetum, Vaccinio myrtilli-Pinetum subass. molinietosum Tilio-Carpinetum, Carici elongatae-Alnetum.*

A further 3 series of large cross captures, which differed from the preceding captures only in that the length of the rows was extended to 300 m, and the traps in the row spaced every 30 m were made in the same area.

2. RESULTS

Analysis was made in this study of material for the two most numerously occurring species, *C. glareolus* (Schreber, 1780) and *Apodemus flavicollis* (Melchior, 1834). In all 698 individuals of *C. glareolus* and 131 of *A. flavicollis* were caught in ten standard captures. The number of individuals caught in the various series of captures are given in Table 1.

Table 1.
Number of rodents caught in standard captures.

Station	*C. glareolus*			*A. flavicollis*		
	Total number	With fuchsin	Without fuchsin	Total number	With fuchsin	Without fuchsin
CP	0	0	0	30	26	4
D	145	76	69	9	4	5
PQ-1	68	61	7	24	21	3
PQ-2	185	151	34	16	8	8
PQ-3	102	89	13	23	15	8
VP-1	18	16	2	0	0	0
VP-2	88	79	9	9	6	3
VP-3	5	5	0	4	4	0
VP-4	47	44	3	8	5	3
VP-5	40	37	3	8	6	2
Total	698	558	140	131	95	36

Two hundred fourteen individuals of *C. glareolus* and 103 of *A. flavicollis* were caught (Table 2) in the 8 series of small cross captures, 67 individuals of *C. glareolus* and 32 individuals of *A. flavicollis* (Table 2) were caught in the three series of large cross captures.

Table 2.
Number of rodents caught in cross captures.

Categories of individuals	Small crosses		Large crosses	
	C. glareolus	*A. flavicollis*	*C. glareolus*	*A. flavicollis*
Total number	214	103	67	32
Without fuchsin	137	50	4	18
With fuchsin	77	53	33	14
% with fuchsin	36	51	49	44

2.1. Occurrence of Fuchsin in Individuals Caught in Standard Captures

Bank Voles containing fuchsin form 80% of all the individuals of *C. glareolus* caught, and in the case of *A. flavicollis* individuals containing fuchsin form 72%. The same percentage of individuals containing fuchsin occurs among both males and females (Table 3).

No differences were found between the mean body weight of individuals of *C. glareolus* with fuchsin (17.1) or without fuchsin (17.5). Similarly, in the case of *A. flavicollis,* the mean body weight of individuals with fuchsin was 20.7 g and without fuchsin 23.1 g. The differences observed in both cases are not statistically significant. Pregnant females were not included in the analysis.

Table 3.
Percentage of individuals with fuchsin among males and females.

Categories of individuals	*C. glareolus*		*A. flavicollis*	
	♂	♀	♂	♀
Total number	361	315	69	64
With fuchsin	297	246	47	46
% with fuchsin	82.3	78.1	68	72

The age of individuals of *C. glareolus* was determined on the basis of length of oral root of M_1 (Wasilewski, 1952, Zejda 1961, Mazák 1963). The mean age of individuals containing fuchsin was 3.9 months, without fuchsin 3.6 months. These differences are not statistically significant.

The whole area divided into an external belt, formed by the three outer rows and lines of traps, and the middle square. There were 156

Table 4.
Distribution of captures of individuals with fuchsin on standard trapping areas.

Species	Internal square		External belt	
	N	% with fuchsin	N	% with fuchsin
C. glareolus	151	80	547	80
A. flavicollis	23	69	108	73

points with traps in the belt and 100 in the square. The percentage of individuals with fuchsin among the rodents caught in the border and in the square was next assessed (Table 4). No differences were found between the percentage of individuals containing fuchsin in the border and the square.

The analysis made showed that there were no differences between the individuals with and without fuchsin analysed in respect of sex, body weight, age and place of capture.

2.2. Analysis of Trappability in Successive Days of Standard Captures

2.2.1. Calculation Method

The probability of capture in successive days of trapping was estimated using the calculation method proposed by Janion, Ryszkowski & Wierzbowska (1968). The mean number of days between the time of setting the traps to observation of the presence of individuals, *i.e.* their capture, was calculated, in other words, the number of individuals caught on a given day was multiplied by the interval measured in days from the time of setting the traps.

The number of individuals caught on the first days was multiplied by 0, as the rodents were caught within a period shorter than one day, the second day by one day *etc.* The products obtained were next added up and divided by the number of individuals caught during the whole capture period. The value obtained was indicated as $E_{1,k}(x)$.

The mean probability of capture was calculated from the formula (Janion, Ryszkowski & Wierzbowska, 1968):

$$E_{1,k}(x) = \frac{q}{p} - \frac{kq^k}{1-q^k} \; \ldots\ldots \qquad (1)$$

where p = probability of capture,

$q = 1 - p$,

k = number of days of capture.

Using the tables published in the study by Janion, Ryszkowski & Wierzbowska (1968) giving the p values depending on the empirically obtained value $E_{1,k}(x)$, it is possible to calculate p values without the necessity for making use of the formula (1) each time. The mean probability of capture of p for the whole trapping period was calculated as above.

When we estimate probability of capture on the basis of material obtained from only a few days trapping, forming part of a whole series of captures — we use the following formula (Janion, Ryszkowski & Wierzbowska, 1968).

$$E_{a,b}(X) = \frac{q}{p} + (a-1) - \frac{(b-a+1)\,q^{b-a+1}}{1-q^{b-a+1}} \; \ldots\ldots \qquad (2)$$

where a indicates the first analysed captures from the given series, b the final captures from the same series. *E.g.* when $a = 2$, $b = 3$, only material from the second and third day of captures was taken for purposes of calculation. $E_{a,b}(X)$ is the mean number of days between setting the traps and manifestation of the individuals presence calculated on the basis of data obtained in the period analysed, that is, from capture a to capture b.

When calculating $E_{a,b}(X)$ it must be remembered that time is counted from the moment of setting up the traps. Thus when the period from $a = 3$ or $b = 4$ is used for analysis, the number of individuals captured in the third trapping is multiplied by the 2 days from the time of setting up the traps, and the number of individuals caught in the fourth trapping by 3 days. We add these values to each other and divide by the number of individuals caught in these two trappings.

We indicate the value obtained by $E_{3,4}(X)$. As in the case of formula (1) use was made of the tables published in the study by Janion, Ryszkowski & Wierzbowska (1968), making it possible to find the value of the corresponding probability of capture p for the calculated values $E_{a,b}(X)$. Knowing the probability of capture p, we can calculate the probability of non-capture q, as $q = 1 - p$. It is possible, on the basis of the formulae given in the study by J a n i o n, *et al.* (1968), to estimate the total number of animals in the study area (N).

When we analyse the whole capture period, we make the estimate of all the individuals according to the formula:

$$N = \frac{N_{1,k}}{1 - q^k} \ \ldots\ldots \quad (3)$$

where $N_{1,k}$ is the sum total of all individuals caught in the whole series of captures.

When the estimate of numbers for the whole series of captures is made on the basis of materials from the shorter period a, b then we use the formula:

$$N = \frac{N_{a,b}}{q^{a-1}(1 - q^{b-a+1})} \ \ldots\ldots \quad (4)$$

where $N_{a,b}$ is the sum total of captured individuals in the a, b period distinguished.

The values of the expression $[1 - q^k]$ and $[q^{a-1}(1 - q^{b-a+1})]$ are to be found, depending on the q values calculated, in the tables published in the study by J a n i o n, *et al.* (1968).

2.2.2. Analysis of Material

The total number of individuals captured in successive days of trapping obtained from totalling all the series of captures, is set out in Table 5. By calculating for the above materials the mean period of manifestation of presence we obtain for *C. glareolus* $E_{1,5} = 0.475$, and probability of captures $p = 0.67$. The corresponding figures for *A. flavicollis* are $E_{1,k} = 1.129$ and $p = 0.4$ (Table 6).

In the case of both the species analysed it was found that individuals with fuchsin had a greater probability of capture than those without fuchsin (Table 6).

In the later part of this study a detailed analysis of probability of capture for individuals with and without fuchsin was made for *C. glareolus* only, as the most numerously occurring species.

By calculating the probability of capture for *C. glareolus* for two consecutive trappings was shown that the probability of capture decreased as trapping proceeds (Table 7). When the capture of individuals with and without fuchsin is examined separately (Table 5) it was found that there was also a change in probability of capture between successive trappings (Table 7). As the probability of capture changes during the process of trapping, the estimates of numbers over the whole trapping period, obtained on the basis of analysis of successive pairs of captures, also change (Table 7).

Probability of capture of individuals of *C. glareolus* with and without fuchsin over the course of trapping operations was calculated separately for the external belt (three outside rows and lines of traps) and the middle square (Table 8). Complete capture of individuals, both with

Table 5.
Number of rodents caught in successive days.

Species	Consecutive inspections	Whole area			Internal square			External belt		
		Total number	With fuchsin	Without fuchsin	Total number	With fuchsin	Without fuchsin	Total number	With fuchsin	Without fuchsin
C. glareolus	1	509	424	85	122	101	21	387	323	64
	2	109	79	30	20	15	5	89	64	25
	3	38	25	13	6	3	3	32	22	10
	4	21	15	6	1	1	0	20	14	6
	5	21	15	6	2	1	1	19	14	6
	Total from 5 days	698	558	140	151	121	30	547	437	110
A. flavicollis	1	59	47	12	7	5	2	52	42	10
	2	31	20	11	11	8	3	20	12	8
	3	16	11	5	3	2	1	13	9	4
	4	15	10	5	1	0	1	14	10	4
	5	10	7	3	1	1	0	9	6	3
	Total from 5 days	131	95	36	23	16	7	108	79	29

Table 6.
Average probability of capture for the whole trapping operation.

Species	Place of capture	Categories of individuals	$E_{1,5}$	$P_{1,5}$	$N_{1,5}$
C. glareolus	Whole area	Total number	0.475	0.67	702
		With fuchsin	0.419	0.70	559
		Without fuchsin	0.700	0.55	143
	Internal square	Total number	0.284	0.75	151
		With fuchsin	0.231	0.80	121
		Without fuchsin	0.500	0.65	36
	External belt	Total number	0.528	0.65	549
		With fuchsin	0.471	0.65	439
		Without fuchsin	0.754	0.55	112
A. flavicollis	Whole area	Total number	1.129	0.40	142
		With fuchsin	1.052	0.40	103
		Without fuchsin	1.333	0.30	43

and without fuchsin, ended, practically speaking, on the third day in the square (Table 5). On successive days the probability of capture of individuals with fuchsin in the square was constant, while in the external belt it decreased on successive days (Table 8). The greatest

Table 7.
Variations in probability of capture of *C. glareolus* in successive trapping and estimated numbers of individuals.

Categories of individuals	Parameters	Successive captures used for calculations 1,2	2,3	3,4	4,5
Total number	*E*	0.18	1.26	2.35	3.50
	P	0.75	0.65	0.45	< 0.05
	N	659	478	280	—
With fuchsin	*E*	0.16	1.24	2.25	3.50
	P	0.80	0.65	0.65	< 0.05
	N	524	339	372	—
Without fuchsin	*E*	0.26	1.30	2.32	3.50
	P	0.65	0.55	0.50	< 0.05
	N	131	120	101	—

Table 8.
Variations in probability of capture of the bank vole in the border and middle square.

Place of capture	Categories of individuals	Parameters	Successive captures used for calculations 1,2	2,3	3,4	4,5
Internal square	With fuchsin	*E*	0.13	1.16	2.14	0
		P	0.85	0.80	0.85	0
		N	119	94	32	0
	Without fuchsin	*E*	0.19	1.37	0	0
		P	0.75	0.40	0	0
		N	29	21	0	0
External belt	With fuchsin	*E*	0.16	1.25	2.39	3.50
		P	0.80	0.65	0.35	< 0.05
		N	403	280	149	—
	Without fnchsin	*E*	0.28	1.29	2.37	3.45
		P	0.60	0.60	0.40	0.15
		N	106	104	69	65

average probability of capture for the whole period occurred among individuals with fuchsin caught in the square, and was $p = 0.8$ (Table 6), but is the smallest for individuals without fuchsin in the border, where it was $p = 0.55$ (Table 6).

In order to check whether constant probability undergoes change on successive days if we reduce the size of the middle square, an analysis was made of material from the small square made by excluding the four outer rows and lines. Since the numbers of *A. flavicollis* were small as we had done previously, the analysis was made for *C. glareolus* only (Table 9). As almost all the individuals were caught by the third

Table 9.
Captures of *C. glareolus* in successive days for the small square.

Categories	Successive days of removal					
	1	2	3	4	5	Total
Total number	88	14	4	1	1	108
With fuchsin	78	12	2	1	1	94
Without fuchsin	10	2	2	0	0	14

trapping, the probability of capture was calculated for this period only. Probability of capture on successive days for individuals with fuchsin was 0.85 and is the same as in the large square. Probability of capture of individuals in the small square without fuchsin is similar to the probability obtained for individuals with fuchsin (Table 10).

Table 10.
Variations in probability of capture in smaller square for *C. glareolus*.

Categories	Parameters	Successive captures used for calculations	
		1,2	2,3
Total number	*E*	0.137	1.220
	P	0.85	0.70
	N	102	66
With fuchsin	*E*	0.133	1.125
	P	0.85	0.85
	N	92	95
Without fuchsin	*E*	0.166	1.500
	P	0.80	< 0.05
	N	12	—

When a comparison is made for individuals with fuchsin of the probabilities of capture from the small and large squares on the various areas we find that they are very great (minimum value $p = 0.63$), and very similar (Table 11), despite the fact that we had to deal with very small numbers for each area.

2.3. Analysis of Range of Penetration

2.3.1. Transects

On account of the small number of animals caught in the transections all the material was added together (Table 12). Captures were begun three days later in the transections than on the standard areas, when the number of individuals trapped on these areas was already small.

Table 11.

Comparison of probability of capture for squares on different trapping areas.

Area	Large square	Small square
D	0.75	0.75
PQ-1	0.75	1.00
PQ-2	0.90	0.90
PQ-3	0.66	0.63
VP-1	1.00	1.00
VP-2	0.83	0.87
VP-3	1.00	1.00
VP-4	0.90	0.83
VP-5	0.75	—

Table 12.

Number of mice caught in transects.

Species	Categories	Distance in m.										Total	Mean (m)
		15	30	45	60	75	90	105	120	135	150		
C. glareolus	With fuchsin	1	1	5	6	3	7	6	3	2	4	38	88
	Without fuchsin			2	5	1		7	2	3	3	23	—
A. flavicollis	With fuchsin		1	2	1		1	1	1	1		8	—
	Without fuchsin				1							1	—

In spite of this, however, among the 61 individuals of *C. glareolus* caught in the transections, 63% contained fuchsin and among 9 individuals of *A. flavicollis* 8 individuals contained fuchsin. The mean distance of trapping from the standard areas was 88 m for *C. glareolus*.

2.3.2. Small Crosses

When totalling all the results of captures (Table 2) it was found that 36% of the individuals of *C. glareolus* and 51% of *A. flavicollis* contain fuchsin. The mean distance from the baiting point for individuals containing fuchsin was 59 m for *C. glareolus* and 64 m for *A. flavicollis*. By calculating the mean distance for successive days of capture for *C. glareolus* (Table 13) it was found that this distance is: first day 58, second day 51 and third day 68 m, and correspondingly for *A. flavicollis:* 71, 36 and 82 m.

Table 13.

Distribution of captures at different distances from bait in small crosses.

Species	Category	Days of removal	Distance in m. 15	30	45	60	75	90	105	120	135	150	Total
C. glareolus	With fuchsin	1	12	10	8	5	4	2	4	3	3	2	53
		2	4	3	0	0	0	0	2	0	0	1	10
		3	3	3	1	0	1	1	2	1	1	1	14
	Without fuschin	1	5	7	9	11	10	13	11	9	7	11	93
		2	8	4	2	3	1	5	2	2	3	5	35
		3	0	0	1	3	0	2	1	0	1	1	9
A. flavicollis	With fuchsin	1	3	8	2	6	1	4	1	4	4	1	34
		2	4	4	3	0	2	0	0	0	0	0	13
		3	0	1	1	1	0	0	1	1	1	0	6
	Without fuchsin	1	4	1	3	2	5	3	1	1	7	1	28
		2	0	2	3	0	0	2	2	2	0	5	16
		3	1	0	1	1	1	0	0	1	0	1	6

Analysing the number of individuals with and without fuchsin caught on small crosses on consecutive days we find that their number decreases. Only a small number of individuals was trapped (Table 13) on the third day. In estimating probability of capture for *C. glareolus* with fuchsin on the first two days of capture on the crosses, it was calculated that $p = 0.75$, but for the second and third day $p = 0.30$. In comparison with the corresponding probabilities of capture of all individuals with fuchsin obtained for standard captures ($p_{1,2} = 0.80$; $p_{2,3} = 0.65$) we find a far more distinct change in trappability during captures on crosses. For the first two days the probability of capture of individuals of *C. glarealus* without fuchsin was 0.60, and 0.75 for the second and third day. This situation is the reverse of that found for capture of individuals without fuchsin from the whole standard area, where the probability of capture decreases ($p_{1,2} = 0.65$; $p_{2,3} = 0.55$).

2.3.3. Large Crosses

When adding all the results of the captures (Table 2) together, it was found that 49% of the individuals of *C. glareolus* and 44% of *A. flavicollis* contain fuchsin. The estimates obtained do not differ from the results obtained for the small crosses (differences not statistically significant). The mean distance, calculated jointly for three days on account of the small amount of material, was 157 m for *C. glareolus* and 180 m for *A. flavicollis*. In comparison with the mean distance for the small crosses (*C. glareolus* 59 m; *A. flavicollis* 64 m) the result obtained in the estimate is greater, which indicates that the values obtained do not define the range of penetration of the rodents.

3. ESTIMATE OF DENSITY AND SUMMING UP OF RESULTS

Calculating for all the standard captures the number of individuals per unit of border (three outside rows and lines) and middle square it was found that twice as many individuals are caught in the border (Table 14) than in the square. For different areas the ratio of individuals caught in the border is also greater than in the square (Table 14). Similar results were obtained in captures on study areas by Pelikán, Zejda & Holišova (1964), Ryszkowski, Andrzejewski & Petrusewicz (1966), Grodziński, Pucek & Ryszkowski (1966), Chełkowska & Ryszkowski (1967), Pelikán (1967) and on the ends of trapping lines by Calhoun & Cosby (1958). The increase in number of individuals on the margin (margin effect) is interpreted as the result of: (a) immigration — Pe-

Table 14.
Number of captures of individuals per 1 point for *C. glareolus*.

Area	Internal square, 100 points	External belt, 156 points
All trapping areas	1.51	3.50
D	0.22	0.34
PQ-1	0.08	0.32
PQ-2	0.35	0.71
PQ-3	0.20	0.43
VP-1	0.02	0.08
VP-2	0.18	0.38
VP-3	0.01	0.03
VP-4	0.09	0.21
VP-5	0.04	0.20

likán, Zejda & Holišova (1964), Pelikán (1967); (b) differentiation of home range of rodents — Calhoun & Cosby (1958); (c) captures of individuals resident outside the border of the study area, sporadically visiting the study area — Chełkowska & Ryszkowski (1967).

The results obtained in this study indicate that:

(1) no differences were found between the mean weight and age of individuals with and without fuchsin. The same percentage of males and females contained fuchsin. No differences were found between the percentage of individuals containing fuchsin in the square and in the border. This indicates that individuals with and without fuchsin come from a homogeneous group.

(2) It must be assumed that individuals with fuchsin were resident animals, as they must have been present in the area or its vicinity during the period between eating the bait and capture in the trap.

(3) Captures in the transects showed that individuals containing fuchsin remain near the capture area from the fourth to the sixth day after the start of captures despite the fact that complete capture of these individuals ended, practically speaking, on the third day in the middle square. It may be assumed that voles containing fuchsin caught in the transects are individuals, the greater part of home range of which lies outside the capture area. Capture of these individuals within the trapping area will be defined by two factors: (a) probability of the presence in the trapping area, (b) probability of capture when they are present within the trapping area.

(4) Individuals with fuchsin caught in the middle square exhibited the greatest probability of capture, not varying in successive days. Hence it may be accepted that a change in probability of capture on successive days for individuals containing fuchsin from the whole area is connected with individuals caught on the external belt, and thus with individuals whose home ranges were intersected by the borders of the study areas.

(5) Comparison of probability of capture of rodents with fuchsin for consecutive trapping days showed that it is uniform in the small (64 points) and large (100 points) squares, the probabilities of capture separately for animals with and without fuchsin being similar in the smaller square, which was not found to be the case in the large square. It may therefore be assumed that individuals which have their home ranges within the trapping areas and had not managed to eat the food stained with fuchsin during the baiting period, exhibit a similar probability of capture to that of individuals with fuchsin present within the trapping area.

(6) The smaller the part of the rodents' home range within the trapping area, the greater the chance these individuals had of not eating the stained bait during the three-day baiting period.

(7) On the basis of the above conclusions it may be accepted that the number of individuals in the area consists of individuals whose home ranges are situated within the study area and of individuals whose home ranges are intersected by this area. As a result of this the estimate of density obtained by dividing the number of individuals caught by the size of the area is overestimated. Material obtained from the transections and crosses indicates that the range of penetration of the rodents is considerable, but cannot be assessed on the basis of the material obtained in this study.

Bearing in mind that complete capture of individuals in the middle square ends, practically speaking, on the third day and that probability of capture is greatest and constant on successive days, it may be

Table 15.
Estimates of density per 1 ha for *C. glareolus*.

Area	Density in internal square	
	Empirical	Estimated from formula (2)
D	22.5	22.5
PQ-1	4.4	4.4
PQ-2	23.1	23.1
PQ-3	12.1	12.1
VP-1	1.6	1.6
VP-2	10.4	10.7
VP-3	0.5	0.5
VP-4	5.5	5.5
VP-5	2.7	2.7

assumed that individuals caught in this square describe the complete removal of individuals whose home ranges come within the trapping area, and thus we have not to do here with the margin effect. This means that we have to do with individuals whose capture depends only on probability of capture and not on the product of probability of capture and presence in the trapping area. For the purpose of defining density of the animals only those individuals whose captures are defined solely by probability of capture should be taken. Accepting this criterion, only the captures in the inner square should be used for assessment of density. This estimate is correct when the animals are evenly distributed in the area, since only then will the probability of capture of individuals at each point be similar. Accepting the above assumptions, we assess density in the study area by dividing the number of individuals caught in the middle square by the area of this square. In this way we obtain empirical estimates (Table 15). Assessment of density by means of the formula (2) gives the same results as empirical estimates (Table 15).

The estimates of density made depend on the correctness of many premises. It appears probable, however, that the margin effect is caused chiefly by individuals whose home ranges lie mainly in the vicinity of trapping areas. This is in agreement with results of investigations on the margin effect made by Chełkowska & Ryszkowski (1967) and with the studies made by Calhoun (1964) on settlement by rodents of areas from which all the previous occupants had been removed by captures.

The correctness of the estimate of density proposed in this study depends on whether the assumptions, which will be checked in further investigations, were right.

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Polish Academy of Sciences,
Institute of Ecology,
Warsaw, Nowy Świat 72.

Krystyna ADAMCZYK i Lech RYSZKOWSKI

OCENA ZAGĘSZCZENIA POPULACJI GRYZONI PRZY UŻYCIU BARWIONEJ PRZYNĘTY

Streszczenie

W wyniku badań laboratoryjnych stwierdzono, że łuskany owies, barwiony fuksyną zasadową utrzymuje się w przewodzie pokarmowym gryzoni do ośmiu dni. Badania terenowe przeprowadzono w kilku biotopach leśnych metodą Standard Minimum. W ostatnich trzech dniach pięciodniowego okresu przynęcania jako przynęty użyto owsa barwionego fuksyną zasadową. Odłów gryzoni trwał 5 dni. W celu określenia zasięgu penetracji gryzoni zastosowano metodę transektów oraz krzyży. Pierwsza z nich polegała na ustawieniu czterech prostopadłych linii o długości 150 m na których ustawiono po dwie pułapki w odstępach 15 m. Linie te, ustawione prostopadle do zewnętrznych rzędów i szeregów powierzchni standardowych, były czynne od czwartego dnia wyłowu na tych powierzchniach. Metoda krzyży polegała na trzydniowym przynęcaniu zwierząt barwionym owsem w punktach odległych od siebie o 15 m, ustawionych w dwóch szeregach o długości 120 m. Przez trzy dni odławiano gryzonie pułapkami zabijającymi, ustawionymi w dwa rzędy, prostopadle i symetrycznie do szeregów, gdzie uprzednio stała przynęta. Długość rzędów wynosiła 150 m a odległość między nimi 30 m. Metodą tą przeprowadzono 11 serii połowów w biotopach leśnych w tym, 3 serie przy odległościach dwukrotnie zwiększonych.

Do analizy wzięto tylko najliczniej łowione gatunki gryzoni *Clethrionomys glareolus* (S c h r e b e r, 1780) reprezentowany przez 698 osobników oraz *Apodemus flavicollis* (M e l c h i o r, 1834) przez 131 osobników.

W wyniku sekcji i przebadania przewodu pokarmowego stwierdzono, że 80% osobników *C. glareolus* i 72% *A. flavicollis* zawierało fuksynę. Należy przypuszczać, że osobniki z fuksyną są osiadłe, ponieważ przebywały na powierzchni badań lub w jej pobliżu w okresie między zjedzeniem przynęty a złowieniem. Analizując osobniki z fuksyną i bez fuksyny nie stwierdzono różnic ciężaru, wieku oraz procentu osobników z fuksyną wśród samców i samic. Wskazuje to, że osobniki z fuksyną i bez fuksyny pochodzą z jednorodnej grupy. Następnie podzielono powierzchnię na zewnętrzny pas i środkowy kwadrat. Stwierdzono, że taki sam procent osobników z fuksyną łowi się na obwodzie i wewnątrz kwadratu co również potwierdza powyższy wniosek. Całkowita liczba zwierząt złowionych na obwodzie, w przeliczeniu na jeden punkt, jest dwukrotnie większa niż w wewnętrznym kwadracie. Jest to efekt krawędzi, który może być wywołany głównie przez osobniki przebywające w sąsiedztwie powierzchni połowów a rewiry ich nieznacznie tylko na tą powierzchnię zachodzą. Zgadza się to z wynikami badań efektu krawędzi przeprowadzonymi przez C h e ł k o w s k ą i R y s z k o w s k i e g o (1967) oraz z badaniami C a l h o u n a (1964) nad zasiedlaniem odłowionych powierzchni przez gryzonie. Osobniki z fuksyną odłowione ze środkowego kwadratu wykazywały największe i niezmieniające się w kolejnych dniach prawdopodobieństwo złowień. Wyłów tych osobników kończy się właściwie trzeciego dnia. Możemy więc przypuszczać, że osobniki te charakteryzują wyłów tych gryzoni, których rewiry mieszczą się w obrębie powierzchni połowów a zakładając równomierność rozmieszczenia gryzoni w terenie ocenę zagęszczenia zwierząt na badanej powierzchni możemy

przeprowadzić dzieląc liczbę zwierząt złowionych w wewnętrznym kwadracie przez jego powierzchnię.

W wyniku połowów krzyżowych stwierdzono, że średnia odległość złowienia osobników *C. glareolus* z fuksyną wynosi 59 m a dla osobników *A. flavicollis* 64 m. Jeżeli zwiększyć dwukrotnie odległości między punktami z przynętą jak i pułapkami, to średnie odległości wynoszą odpowiednio 157 m i 180 m. Połowy na transektach wykazały, że osobniki z fuksyną przebywają w pobliżu powierzchni badań od czwartego do szóstego dnia mimo, że wyłów tej grupy osobników zakończył się wewnątrz powierzchni już trzeciego dnia. Są to osobniki, których znaczna część rewiru leżała poza badaną powierzchnią. Oceny odległości uzyskane metodą krzyży i transektów nie pozwoliły na uzyskanie zasięgu penetracji gryzoni.