KOMITET EKOLOGICZNY – POLSKA AKADEMIA NAUK

EKOLOGIA POLSKA – SERIA A

Tom XI Warszawa 1963 Nr 24

Teresa WIERZBOWSKA and Kazimierz PETRUSEWICZ

RESIDENCY AND RATE OF DISAPPEARANCE OF TWO FREE-LIVING POPULATIONS OF THE HOUSE MOUSE (*MUS MUSCULUS* L.)*

The rate of disappearance of the settled part of the two populations examined is constant (distribution of length of residency has the character of an exponential curve). The length of residency of the populations examined is greater than in small forest rodents.

1. OBJECT AND METHOD

The object of the analysis was formed by the residency of the house mouse (*Mus musculus* L.) at the Field Station of the Institute of Ecology of the Polish Academy of Sciences at Dziekanów. The building investigated is situated in a wood (Kampinos National Park); the distance to the nearest village is about 1 km through a wood constantly inhabitated by predators (tawny owl, kestrel, weasel and others); it must therefore be taken that the house mice in question were somewhat strongly isolated.

*From the Institute of Ecology Polish Academy of Sciences, Warszawa.

The mice in the building investigated were completely protected: they were caught in live-traps for the purposes of the investigations only and released on the spot on which they had been caught immediately after marking or reading the mark which they had already received.

The mice in this building lived in two habitats which differed fairly considerably as regards ecological conditions and were more or less isolated; in the attic and in the used part of the building (laboratories, kitchens, store-room, living rooms etc.) which will be termed "house" in the further part of this paper. In the attic (535 m² in area) the mice were constantly fed, the temperature varied very considerable, both during the day and according to season; in the house there was an abundance of food in certain places (store-room) and in places such as the laboratories there was only occasional food in addition to the bait used in the traps. The temperature was more or less constant (room temperature). The settlements in the attic and house formed two separate and independent populations[1]. This is borne out by the following two facts: although – as shown in other paper (Petrusewicz and Andrzejewski 1962) and data unpublished (Petrusewicz and Kaczmarzyk – in litt.), the attic and house populations had opportunities of contact, such contacts were rather the exception – the populations exhibited a considerable degree of isolation (of the 429 individuals found during two years of observations, only 21 transfers were observed). Variations in numbers of mice settling in the attic and house exhibited a complete lack of agreement and connection.

Information was obtained by the catch-mark-release (CMR) method on the population conditioned to a capture site by means of livetraps with bait (cats) in the house, and to traps set in the feedingboxes in the attic. Captures were made once a week, the traps being inspected at 8 a. m., 12 noon, 4. p.m., 8 p.m., and 8 a.m. the next day. On the remaining days the traps in the house were left baited with oats but not set to spring shut; in the attic the traps were removed from the feedingboxes.

A general description of the material is given in Tab. I.

Work on the material was carried out by means of a calendar of catches (Petrusewicz and Andrzejewski 1962). As stated previously (Andrzejewski and Wierzbowska 1961, Petrusewicz and Andrzejewski 1962) the calendar of catches made it possible to distinguish: 1) open-and-shut settled mice, i.e. mice which spent a week or more in the study area and 2) ephemeral mice, i.e. mice which are caught on one inspection day only never appear again. The ecological characteristics of these two groups of mice are given in the paper by Petrusewicz and Andrzejewski (1962).

[1] A full description of the history of these two populations is to be found in the paper by Petrusewicz and Andrzejewski (1962) and Petrusewicz and Kaczmarzyk (in litt.). Only the most general data are given in the present paper.

Description of the material analysed

Tab. I

Place	Weeks of investigation	No of individuals			No of catches		
		mice	♂♂	♀♀	mice	♂♂	♀♀
Attic	88	254	111	143	1186	719	467
House	140	355	165	190	1251	596	655

A statistical description of these two groups (s-mice and e-mice) simultaneously constituting a statistical justification for the division of the population into these two categories was made in a similar way to that made for small forest rodents in the paper by Andrzejewski and Wierzbowska (1961).

The population living in the house was not uniform: it was possible to distinguish in it the settlement of mice in the domestic part of the house (store-room, kitchen, canteen) living in relatively good conditions from the food aspect, and the settlement of mice in the laboratories, where food conditions were rather poor. The domestic part and the laboratories were connected by wide stairs, but the majority of the mice were caught either in the functional part or in the laboratories. Three groups can therefore be distinguished in the house population: the domestic (exclusively), the laboratory (exclusively) groups and a group of mice caught both in the laboratories and in the domestic rooms, which we shall now term the "common" group. This grouping is justified not only by the differences in their habitats. As shown by other investigations (Petrusewicz and Kaczmarzyk (in litt.)) many of the ecological characteristics of the household and laboratory groups differ from each other and also from the analogical characteristics of the "common" group.

For this reason also, wherever possible, ecological parameters were calculated not only for the whole of the house population, but also separately for the intrapopulation groups: domestic, laboratory and common.

It was possible to make calculations for each group for the parameters which do not depend on the number of ephemeral mice, since the number of ephemeral mice in each group is not known. *Ex definitione* the "common" group is composed by the mice which are caught both in the domestic and laboratory parts of the house, i.e. which live at least one week in the study area, and are therefore open-and-shut mice. It was therefore possible to calculate and analyse the parameters for each group in cases when calculations were based on the distribution of length of residency of open-and-shut mice, that is: the character of the distribution of the curve of length of residency, rate of disappearance and mean length of stay. The numbers of each ecological category of mice and the indices of residency or migratory tendencies, as being based on the numbers of ephemeral mice, could be calculated only for the house population as a whole.

2. ANALYSIS OF THE MATERIAL

2. 1. Distribution of length of stay

Investigation was made of whether the curve of distribution of length of residency of the mice in the habitats examined is of an exponential character. Andrzejewski and Wierzbowska (1961) found that the distribution of length of stay of open-and-shut mice is exponential in character, while the distribution of the life span of all the mice differs from the exponential curve. Taking this as a basis, statistical analysis was made, first of all, of the open-and-shut mice in the attic and house populations, and the groups of this latter population.

The following were determined for the analysis of open-and-shut mice:

N_t – the number of individuals living in the study area for at least t weeks ($t = 1, 2, 3, \ldots$);

$\widetilde{N}_t$ – number of individuals staying exactly t weeks ($t = 1, 2, 3, \ldots$).

Calculation was next made of the theoretical number of mice which would have stayed t weeks ($\widetilde{N}_t'$) in the study area if the distribution of their length of stay had in fact been exponential. Calculation was made by means of the formula:

$$\widetilde{N}_t' = N_1 \cdot e^{-\mu t} \cdot (e^{\mu} - 1) \text{ for } t \geqslant 1$$

where N_1 is the number of individuals staying at least a week, and thus open-and-shut mice, μ - index of the rate of disappearance of individuals from the study area, the estimation of which is the expression:

$$\mu = \frac{1}{\bar{t} - 1}$$

obtained by the method of maximum likelyhood, where $\bar{t}$ – mean duration of stay of open-and-shut mice in the study area (for the sake of simplifying symbols, the values $\bar{t}$, μ, $\widetilde{N}_t'$ and their values calculated on the basis of the material analysed are indicated by the same symbols).

Values N_t, $\widetilde{N}_t$, $\widetilde{N}_t'$ for the attic and values N_t for all the groups of mice examined are given in Table II, while the estimated values μ are given in Table III.

The differences between the theoretical and empirical data were examined

Distribution of duration of stay of house mice in study areas and statistical analysis of disappearance of attic population

Tab. II

	Attic				House	Laboratory part	Domestic part	Common part
t	N_t	$\tilde{N}_t$	$\tilde{N}'_t$	χ^2_t	N_t	N_t	N_t	N_t
0	254	77			355			
1	177	19	17.164	0.1964	211	80	94	37
2	158	17	15.499	0.1454	189	70	85	34
3	144	11	13.996	0.6414	165	56	77	32
4	130	14	12.639	0.1466	149	49	71	29
5	116	11	11.413	0.0149	134	41	65	28
6	105	13	10.306	0.7042	128	40	60	26
7	92	13	9.307	1.4692	118	36	56	26
8	79	6	8.404	2.2463	111	30	55	24
9	73	4	7.598		99	26	49	24
10	69	8	6.853	0.0704	88	24	41	23
11	61	6	6.189		78	20	38	20
12	55	3	5.589	2.9871	70	18	33	19
13	52	2	5.047		63	17	28	18
14	50	2	4.557		58	13	27	18
15	48	6	4.115	0.4604	55	13	25	17
16	42	2	3.716		53	13	23	17
17	40	3	3.356		47	11	22	14
18	37	2	3.031	0.0141	44	11	20	13
19	35	3	2.737		41	10	18	13
20	32	4	2.471		39	10	17	12
21	28	2	2.232		34	7	16	11
22	26	5	2.015		33	7	15	11
23	21	3	1.820	0.3549	31	6	15	10
24	18	0	1.643		29	6	13	10
25	18	1	1.484		27	6	12	9
26	17	4	1.340		24	5	10	9
27	13	1	1.210		23	5	10	8
28	12	2	1.093		22	5	10	7
29	10	1	0.987		20	4	9	7
30	9	0	0.891		18	4	8	6
31	9	3	0.805		17	3	8	6
32	6	0	0.727		14	3	7	4
33	6	2	0.654		13	2	7	4
34	4	1	0.591	1.7495	12	2	6	4
35	3	0	0.535		9	2	3	4
36	3	0	0.484		8	1	3	4
37	3	1	0.438		6	1	3	2
38	2	0	0.392		5	1	2	2
:	:	:	0.355		:	:	:	:
40	2	0	0.321		5	1	2	2
41	2	0	0.291		3	1	1	1
:	:	:	0.905		:	:	:	:
46	2	0	0.175		3	1	1	1
47	1	1	0.158		3	1	1	1
48					3	1	1	1
:				11.2008	:	:	:	:
52					3	1	1	1
53					2	1	1	1
:					:	:	:	:
65					2	1	1	1

Rate of disappearance and length of the ecological life of settled mice
[house mouse and three species of forest rodents (after Andrzejewski and Wierzbowska 1961 completed)]

Tab. III

Index	*Mus musculus* L.					*Clethrionomys glareolus* Schreb.			*Apodemus agrarius* Pall.			*Apodemus flavicollis* Melch.
	attic	house	laboratory part	domestic part	common part	1955/56	1956/57	1957/58	1955/56	1956/57	1957/58	1955/56
$\mu \cdot 100$	10.2	9.4	12.7	9.0	6.5	12.8	22.3	22.2	23.2	30.7	26.9	19.03
$\bar{t}'$	9.8	10.6	7.9	11.1	15.4	7.8	4.5	4.5	4.3	3.3	3.7	5.3
$S_{(\bar{t}')}$	0.7	0.7	0.8	1.1	2.5	0.6	0.4	0.5	0.4	0.2	0.6	0.6

Calculation of the value of the statistic $\omega^2_{N_1}$ for the attic area

Tab. IV

t	$\tilde{N}_t$	$\bar{\bar{N}}_t$	$-\ln F(t)$	$j_1(t)$	$-\ln F(t)\, j_1(t)$	$-\ln[1-F(t)]$	$j_2(t)$	$-\ln[1-F(t)]\, j_2(t)$
1	19							
2	17	19	2.3331	380	886.5780	0.1020	6384	651.1680
3	11	36	1.6874	952	1606.4048	0.2046	5100	1043.4600
4	14	47	1.3318	924	1230.5832	0.3065	2992	917.0480
5	11	61	1.0936	1526	1668.8336	0.4080	3458	1410.8640
6	13	72	0.9188	1474	1354.3112	0.5108	2442	1247.3736
7	13	85	0.7809	2054	1603.9686	0.6125	2574	1576.5750
8	6	98	0.6733	2392	1610.5336	0.7134	2236	1595.1624
9	4	104	0.5834	1218	710.5812	0.8165	918	749.5470
10	8	108	0.5092	852	433.8384	0.9188	572	525.5536
11	6	116	0.4479	1800	806.2200	1.0189	1048	1067.8072
12	3	122	0.3945	1434	565.7130	1.1209	702	786.8718
13	2	125	0.3481	744	258.9864	1.2242	324	396.6408
14	2	127	0.3093	506	156.5058	1.3243	206	272.8058
15	6	129	0.2744	514	141.0416	1.4271	198	282.5658
16	2	135	0.2446	1590	388.9140	1.5279	546	834.2334
17	3	137	0.2182	546	119.1372	1.6296	166	270.5136
18	2	140	0.1948	834	162.4632	1.7316	234	405.1944
19	3	142	0.1732	566	98.0312	1.8389	146	268.4794
20	4	145	0.1555	864	134.3520	1.9379	204	395.3316
21	2	149	0.1393	1180	164.3740	2.0402	244	497.8088
22	5	151	0.1244	602	74.8888	2.1456	110	236.0160
23	3	156	0.1121	1540	172.6340	2.2443	240	538.6320
24	0	159	0.1009	948	95.6532	2.3456	120	281.4720
25	1	159						
26	4	160	0.0812	320	25.9840	2.5511	36	91.8396
27	1	164	0.0737	1300	95.8100	2.6522	124	328.8728
28	2	165	0.0661	330	21.8130	2.7536	26	71.5936
29	1	167	0.0587	666	39.0942	2.8560	46	131.3760
30	0	168	0.0534	336	17.9424	2.9584	20	59.1680
31	3	168						
32	0	171	0.0429	1020	43.7580	3.1630	48	151.8240
33	2	171						
34	1	173	0.0346	690	23.8740	3.3697	22	74.1334
35	0	174	0.0315	348	10.9620	3.4673	8	27.7384
37	1	174						
38	0	175	0.0233	350	8.1550	3.7679	6	22.6074
46	1	175						
47	1	176	0.0090	352	3.1680	4.6896	4	18.7584
48	0	177	0.0080	354	2.8320	4.7903	2	9.5806
	177		13.6311		14737.9396	65.1692		17238.6164

$$\omega^2_{N_1} = 177 - \frac{1}{177}\,[-\,31976\,.\,5560 + 78.8003] = -\,177 + \frac{1}{177}\cdot 31897\,.\,7557 = 3.2133$$

in two ways: by means of Pearson's statistic χ^2 and by means of the statistic $\omega^2_{N_1}$ sensitive to the behaviour of the „tail ends" of the distribution[2].

The results of such an analysis show that the difference between the empirical and theoretical distribution of length of stay is not significant (Tab. V). We must remember that the theoretical data were calculated after assuming that the curve of length of stay is exponential in character; we may therefore state that the mice staying in the study area at least one week (open-and-shut mice) have an exponential distribution of length of stay in the given area. This conclusion is justified not only for the whole attic and house population, but also for the separate groups distinguished in the house population (Tab. V).

Andrzejewski and Wierzbowska (1961) found that the distribution of length of stay, if all the mice recorded (N_o), are analysed differs significantly from the exponential distribution. In the case of the populations examined, such an analysis can only be made for the whole attic and house populations, since we do not know – as already stated – the number of ephemeral mice (and therefore also N_o) of each group.

Comparison was made of the empirical data of the distribution of length of stay of all the mice in the attic and house with analogical theoretical values, calculated according to the formula:

---

[2] An example showing the calculation of the statistic $\omega^2_{N_1}$ (Anderson and Darling 1954), little known among biologists, is given in Table IV. The value of this statistic was calculated according to the formula:

$$\omega^2_{N_1} = -N_1 - \frac{1}{N_1} \cdot \sum_{i=1}^{N_1} (2i-1)\left[\ln u_i + \ln\left(1 - u_{N_1 - i + 1}\right)\right]$$

where:

$$u_i = F(t_i) = 1 - e^{-\mu(t_i - 1)} \quad \text{values } t_i \ (i = 1, 2, 3, \ldots N_1)$$

arranged in a non-descending sequence $t_1 \leqslant t_2 \leqslant \ldots \leqslant t_{N_1}$. The above formula converted to a form more convenient for calculation:

$$\omega^2_{N_1} = -N_1 - \frac{1}{N_1}\left[\sum_{t=2}^{m} j_1(t) \ln F(t) + \sum_{t=2}^{m} j_2(t) \ln[1 - F(t)] + - \sum_{t=2}^{m} \ln F(t) - \sum_{t=2}^{m} \ln[1 - F(t)]\right]$$

where:

$$F(t) = 1 - e^{-\mu(t-1)} \quad (t = 1, 2, 3, \ldots),$$

$$j_1(t) = (2 \cdot \bar{\bar{N}}_t + 1 - \tilde{N}_{t-1}) \cdot \tilde{N}_{t-1},$$

$$j_2(t) = [2 \cdot (N_1 - \bar{\bar{N}}_t) + \tilde{N}_{t-1} + 1] \cdot \tilde{N}_{t-1}$$

N_t, $\tilde{N}_t$ – defined earlier,

$\bar{\bar{N}}_t$ – number of individuals staying less than t weeks (t = 2, 3, 4, ...).

$$\tilde{N}''_t = N_o \cdot e^{-\mu t} (e^{\mu} - 1) \text{ for } t \geqslant 0$$

where $N_o = N_1 \cdot e^{\mu}$ and N_1 is the number of mice staying at least one week.

Results of an analysis of the differences between values of the empirical and theoretical distributions of length of residence of obviously resident mice calculated by the statistics χ^2 and $\omega^2_{N_1}$

Tab. V

Area	Attic	House	Domestic part	Laboratory part	Common part
χ^2	11.2008	14.2365	3.5573	3.9403	0.5244
p	0.51	0.43	0.73	0.42	0.47
$\omega^2_{N_1}$	0.4900	2.1375	1.5992	2.1250	1.1009
$\omega^2_{0.05}$	2.492	2.492	2.492	2.492	2.492

The analysis made showed that the empirical distribution differs significantly from the theoretical distribution (Tab. VI), that is, that the curve illustrating the distribution of all the mice is not an exponential curve.

Significance of differences (measured by the statistic χ^2) between empirical and theoretical values of length of residence of all the mice (together with ephemeral mice)

Tab. VI

Area	Attic	House
χ^2	28.3641	79.4477
p	0.008	<0.001

To sum up: the following conclusions may be drawn:

1) the conclusion of Andrzejewski and Wierzbowska (1961) was confirmed that the settlement of a certain area (population) consists of two separate parts: open-and-shut settled mice (the rate of disappearance from the area of which is constant i.e. the distribution of length of stay is exponential) and the ephemeral part (N_e), the rate of disappearance of which is far higher.

This was confirmed for entire, and well isolated, populations, and also whole intrapopulation groups distinguished from the ecological aspect, and not only – as was the case with rodents in the forest (*op. c.*) – for the settlement of the areas, the settlement of which is the only representation of the population. This provided confirmation of the opinion that this regularity is of a general nature, and not an accident applying to certain populations;

2) The premise was confirmed that ephemeral mice form an ecologically separate part of the population (Andrzejewski and Wierzbowska 1961, Petrusewicz and Andrzejewski 1962, Petrusewicz and Kaczmarzyk in litt.).

2. 2. Number of migratory and settled mice

The group of ephemeral mice (e-mice) requires separate analysis. Taken directly from the calendar of catches, those individuals which live in the study area one or more weeks (i.e. are caught not less than twice and if only twice then with a week's interval between captures at least) may be considered as freshly resident. It may be expected that there are resident mice which, with the method used, will be recorded as residing for a shorter period than one week, i.e. will be included with ephemeral mice. The presence of such individuals may be suspected since trappability is not complete with the capture method used, that is, not every individual is caught every week. It may so happen that a certain individual which resides in the attic for a certain number of weeks – and is therefore in fact freshly resident, is caught once only, and will therefore be counted among the ephemeral mice.

In order to estimate the total number of settled mice, i.e. the sum of open-and-shut mice and settled mice among the ephemeral individuals – which we shall now term pseudo-ephemeral – the following reasoning has been applied:

1) The mean number of captures of open-and-shut mice does not alter during the life of the mice in either the attic (Petrusewicz and Andrzejewski 1962) or in the house; this statement in the case of the house population applying to both the whole population and to each group: household, laboratory and "common" (Petrusewicz and Kaczmarzyk – in litt.). It may therefore be taken that the mean number of captures of pseudo-ephemeral mice (as settled from among the ephemeral mice) will be the same.

2) The distribution of time intervals between successive captures of open-and-shut mice is randomly (Petrusewicz and Andrzejewski 1962, Petrusewicz and Kaczmarzyk in litt.). It may therefore be taken that the ephemeral mice as well (as settled mice) will be caught randomly.

3) The curve of the distribution of length of stay of open-and-shut mice is an exponential curve, i.e. the rate of their disappearance is constant, not depending on the duration of their stay in the population. It may therefore be taken that the pseudoephemeral mice, as well as settled mice, will disappear at the same rate.

On the grounds of these three premises we feel justified in extrapolating the curve of length of stay of open-and-shut mice to a zero point (the first, recording the capture of mice). We therefore extend the function $N'_t = N_1 \cdot e^{-\mu(t-1)}$ for $t \geqslant 1$ to point $t = 0$ and obtain:

$$(1) \quad N_0' = N_1 \cdot e^{\mu}$$

where N_1 is the number of open-and-shut mice. The figure obtained in this expresses the total number of settled mice (N_o') from among all those recorded (N_o). The numbers of settled mice can be calculated even if we do not exactly know the number of ephemeral mice (Tab. VII).

Number of resident mice

Tab. VII

Area	Attic	House	Domestic part	Laboratory part	Common part
N_o'	196	232	104	91	39

The remaining mice in the given population will be migrants (N_m), individuals which do not live in the population examined (are not settled) but merely pass through it. We can calculate their number only for those populations in which we know the total number of mice (N_o) (in our case for the attic population and the whole house population – Tab. VIII).

Number of each ecological category

Tab. VIII

Category of mice		Number		Percent	
		attic	house	attic	house
All	N_o	254	355	100	100
Open-and-shut settled	N_1	177	211	69.7	59.4
Ephemeral	N_e	77	144	30.3	40.5
Migrants	N_m	58	123	22.8	34.6
Pseudomigrants	N_p	19	21	7.5	5.9
Settled	N_o'	196	232	77.2	65.4

Finally there remains the category of ephemeral mice which are settled (pseudomigrants N_p).

The numerical relations between the categories distinguished can be expressed as follows (Fig. 1).

All the individuals in the population: $N_o = N_1 + N_e = N_1 + N_m + N_p$

Open-and-shut $N_1 = N_o - N_e$

Ephemeral $N_e = N_o - N_1 = N_m + N_p$

Settled $N_o' = N_o - N_m = N_1 + N_p$

Migrants $N_m = N_o - N_o' = N_e - N_p = N_o - (N_1 + N_p)$

Pseudomigrants $N_p = N_e - N_m = N_o' - N_1 = N_o - (N_1 + N_m)$.

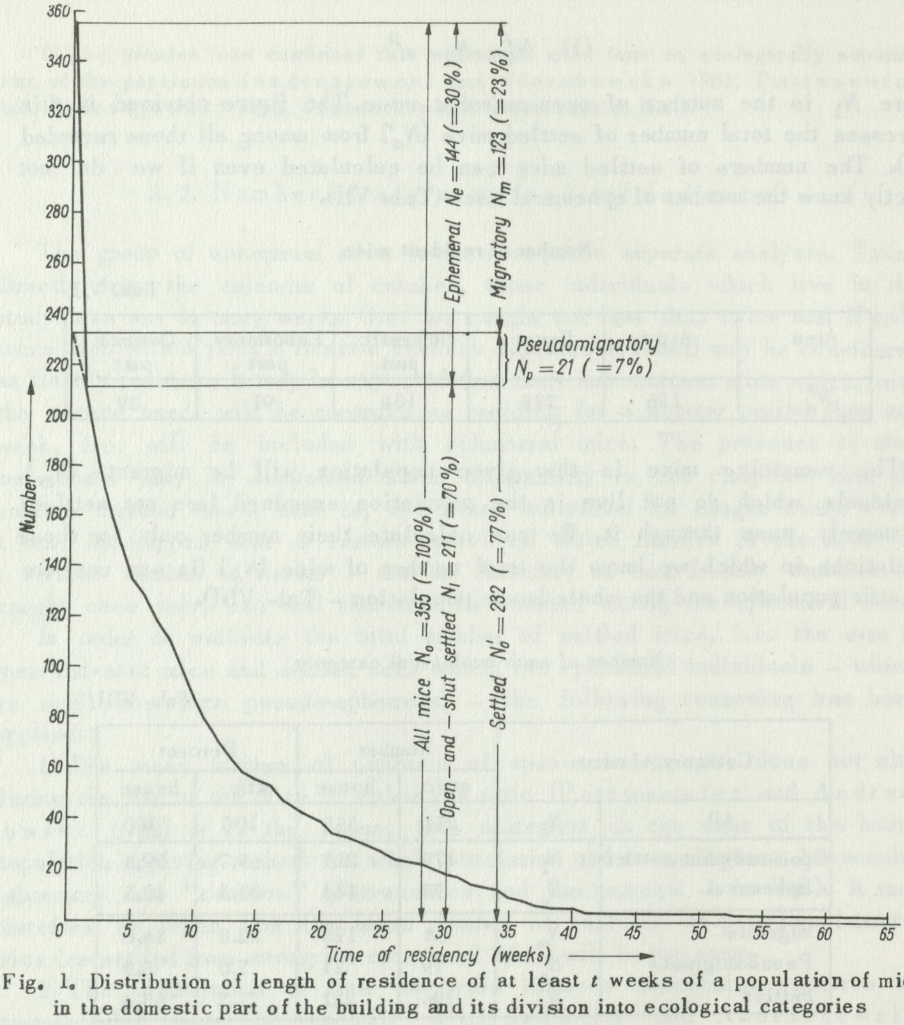

Fig. 1. Distribution of length of residence of at least t weeks of a population of mice in the domestic part of the building and its division into ecological categories

We would point out that settled and migrant mice are homogeneous ecological categories. The open-and-shut mice are, it is true, ecologically homogeneous, but do not include the whole number in their category, but ephemeral mice are a mixed category from the ecological aspect: they contain both settled and migrant individuals. We know, however, the open-and-shut and ephemeral mice *"ad personam"*, while only the number of settled and migrant mice is known. In other words we are able to indicate which individual is ephemeral, but we cannot indicate which individual is a migrant. For many of the investigations a knowledge of a definite individual is essential (e.g. infestation by fleas etc.), and in the same way an analysis of ephemeral versus open-and-shut mice is essential to certain tasks. It must be remembered that we are then investigating a group of open-and-shut mice among which there are only settled mice, but not all the settled mice, and the ephemeral group among which there are both settled and migrating individuals. The differences between the open-and-shut and ephemeral mice can than be attributed to the presencs of migrants among the ephemeral mice. The higher the percentage of migrants among the ephemeral mice, the more certain the conclusion.

Indices illustrating the degrees of residency and migratory tendencies

Tab. IX

Index	Symbol	Attic	House
$\frac{N_o'}{N_o}$	d_1	0.77	0.65
$\frac{N_m}{N_o}$	d_1'	0.23	0.35
$\frac{N_p}{N_e}$	d_2	0.25	0.15
$\frac{N_m}{N_e}$	d_2'	0.75	0.85
$\frac{N_m}{N_o'}$	d_3'	0.30	0.53

In the populations examined migrants form a high percentage of the ephemeral mice [attic – 75% and house – 85% (Tab. IX)].

2. 3. Length of stay and rate of disappearance

The quantitative division of the population into a settled and a migrating part makes it possible to estimate the length of stay in the area of all the settled mice, and therefore of those mice, the number of which in the population is estimated by means of formula (1). Correspondingly the mean length of stay in the area and this error are given by means of the equation:

$$\bar{t}' = \frac{1}{\mu} \qquad S_{(\bar{t}')} = \frac{1}{\mu\sqrt{N_1 \cdot e^{\mu}}}$$

These values, calculated for all the study areas and the values of index μ (in %) are given in Tab. III.

Comparison was next made of the mean length of stay, and thus of the rats of disappearance μ of the two populations analysed, and comparison made with the forest population (Andrzejewski and Wierzbowska 1961). Comparison was made by means of the statistic $F = \frac{\bar{t}_1'}{\bar{t}_2'}$, where $\bar{t}_1'$ and $\bar{t}_2'$ are the length of stay for the first and second population respectively. This statistic has an F distribution about $2N'_{01}$ and $2N'_{02}$ degrees of freedom (N'_{01} – the number of settled mice for the first population, N'_{02} – the number of settled mice for the second population).

The results of comparisons, and there values F from the sample and the probabilities corresponding to them p [$p = P\ (F \geqslant F_p)$] are given for the house (Tab. X) and for the comparison of house with forest (Tab. XI).

Analysis of the significance of differences in length of stay of the mice in the attic and house populations and in the different parts of the latter

Tab. X

Area	Attic				Domestic part		Laboratory part
	house	domestic part	laboratory part	common part	laboratory part	common part	common part
F	1.0857	1.1337	1.2452	1.5694	1.4117	1.3843	1.9543
p	>0.10	>0.10	<0.05	<0.01	<0.01	<0.05	<0.01

3. COMPARISON OF THE POPULATIONS EXAMINED

As the rate of disappearance and numbers of migrants and settled mice are now know, the following properties of the populations examined can then be described: the permanence of residency, and degree of migrational residency tendencies.

Permanency of residency is characterised by the duration of stay, the value of which may also be defined as the "ecological length of life". This may be the mean time or the longest time, depend on what is required. The permanency of residency may also be determined by the rate of disappearance: the higher the rate of disappearance the lower the degree of residency.

Comparison of the populations of attic and house show that they do not differ as to permanency of residency (Tab. III). It is true that the attic population has a slightly longer mean period of residency, but this difference is not significant (Tab. X). It is interesting, however, that the different groups

Analysis of the significance of differences in length of residence of mice in the forest and house populations

Tab. XI

Species	*Clethrionomys glareolus* Schreb.						*Apodemus agrarius* Pall.						*Apodemus flavicollis* Melch.	
Year	1955/56		1956/57		1958/59		1955/56		1956/57		1957/58		1955/56	
Population	attic	house	attic	house	attic	house	attic	house	attic	house	attic	house	attic	house
F	1.2532	1.3606	2.1875	2.3750	2.1778	2.3644	2.2790	2.4744	3.0154	3.2738	2.6415	2.8679	1.8667	2.0267
p	<0.05	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

in the house population have greatly differing mean duration of stay (Tab. III), the differences between these three "sub-populations" being statistically significant (Tab. X). Also all the "sub-populations" in the house differ significantly from the attic population. The population of the domestic and "common" parts exhibits the maximum degree of residency, the minimum is exhibited by the laboratory part.

The lowest degree of residency is exhibited by the laboratory part. This is quite understandable, since they have the worst habitat conditions: no permanent food supply, considerable human activity. It is however interesting that the maximum permanency of residency is exhibited not by the household population, living in what would seem to be the best habitat conditions, but the artificially divided "common part", i.e. mice caught both in the domestic and in the "common" parts. We cannot completely explain this phenomenon. It is possible that the processes taking place, comprehensively discussed in the work by Petrusewicz and Kaczmarzyk (in litt.) are of significance here. It is known from other investigations that settled mice change to a migratory state from time to time and then often become resident again, possibly certain of the mice for some reason pass into a migratory state, and having migrated over the relatively large space from the domestic part of the building to the laboratories, reside in the laboratory part (or vice versa). In this way the duration of stay of at least part of the "common" mice would consist of, as it were, two "periods of residence", and hence would have a higher value.

Comparison of the duration of stay (and rate of disappearance) of house mice with small forest rodents (Andrzejewski and Wierzbowska 1961) distinctly shows the greater degree of residency of house mice (Tab. III). These differences are statistically significant (Tab. XI).

Knowing the number of each category of mice, it is possible to define certain scores describing the degree of residency — or of migrational tendencies of the population.

The degree of residency gives us the percentage of resident mice among all the mice $d_1 = \frac{N_o'}{N_o}$.

The second index describing the degree of residency is the percentage of pseudomigrants among the ephemeral mice (d_2).

The indices of migrational tendencies form a supplement to the scores of residency defined above. In addition a third index was introduced, of migrational tendencies as the percentage of migrants among the resident mice (d_3').

The calculations show that the attic population is more settled than the house population (Tab. IX).

4. CONCLUSIONS

a. In the populations of house mice investigated it is possible to distinguish two separate parts: open-and-shut settled mice (N_1) and ephemeral mice (N_e). The former possess an exponential character of disappearance, and their rate of disappearance is far less than that of the ephemeral mice. This rule applies to the whole populations and also to the intrapopulation groups distinguished from the ecological aspect.

b. The rate of disappearance, and therefore the length of residency of the attic population is the same as in the house population. Significant differences take place only in the intrapopulation groups of the house population: the shortest period of stay is that in the laboratory part: the longest period of stay, and therefore the lowest rate of disappearance is exhibited by the "common" mice. These differences are statistically significant.

c. The length of residence of the attic and house populations is significantly greater than the length of residence of the forest mice.

d. The attic population is more settled than the house population.

REFERENCES

1. Anderson, T. W. and Darling, D. A. 1954 — A test of goodness of fit — J. Amer. Statist. Ass. 49: 765–769.
2. Andrzejewski, R. Wierzbowska, T. 1961 — An attempt at assessing the duration of residence of small rodents in defined forest area and the rate of interchange between individuals — Acta theriol. 4: 153–172.
3. Petrusewicz, K. Andrzejewski, R. 1962 — Natural history of free-living population of house mice (*Mus musculus* Linnaeus) with particular reference to groupings within the population — Ekol. Pol. A, 10: 85–122.

OSIADŁOŚĆ I TEMPO UBYWANIA DWÓCH WOLNOŻYJĄCYCH POPULACJI MYSZY DOMOWEJ (*MUS MUSCULUS* L.)

Streszczenie

Tematem pracy jest analiza zasiedlania przez myszy domowe (*Mus musculus* L.) budynku Stacji Terenowej Zakładu Ekologii PAN w Dziekanowie Leśnym. Badany budynek jest izolowany, gdyż od najbliższych osiedli ludzkich dzieli go ok. 1 km lasu. Składa się on z dwóch siedlisk strychu i pomieszczeń użytkowych (pracownia, kuchnia, magazyn, mieszkania itp.) różnych pod względem warunków ekologicznych. Populacje zasiedlające te dwie powierzchnie były odrębne i samodzielne (Petrusewicz i Andrzejewski 1962, Petrusewicz i Kaczmarzyk in litt.).

Myszy łowiono pułapkami żywołownymi i po odnotowaniu numeru wypuszczano w miejscu złowienia. Połowy przeprowadzano raz na tydzień w godzinach 8, 12, 16, 20 i 8 rano następnego dnia. W pozostałe dni pułapki stały w budynku nie nastawione na zatrzaskiwanie.

Materiały opracowane przy pomocy kalendarza złowień (Petrusewicz i Andrzejewski 1962), który pozwolił rozróżnić myszy jawnie osiadłe, tzn. przebywające co najmniej tydzień oraz myszy efemeryczne, przebywające mniej niż tydzień na badanej powierzchni.

Populacja żyjąca w budynku nie była jednolita. Składała się z grupy „gospodarczej" (myszy łowiące się tylko na tej powierzchni), „pracownianej" (przebywające tylko w pracowni) oraz grupy osobników łowiących się w pracowni i w pomieszczeniach gospodarczych. Podział ten spowodowany był różnorodnością siedliskową oraz różnorodnością wielu charakterystyk ekologicznych (Petrusewicz i Kaczmarzyk in litt.).

Przeprowadzona analiza statystyczna uwzględniała ten podział. Analiza tempa ubywania myszy z powierzchni wykazała, że myszy jawnie osiadłe posiadają wykładniczy rozkład długości przebywania dla wszystkich analizowanych populacji i ich grup. Prawidłowość ta nie zachodzi jeżeli analizować wszystkie odłowione osobniki (łącznie z efemerycznymi). Zbieżność ciągu empirycznego i teoretycznego sprawdzono za pomocą statystyki χ^2 Pearsona oraz statystyki $\omega^2_{N_1}$ dla myszy jawnie osiadłych (tab. V) oraz dla całej populacji (tab. VI).

Możemy zatem powiedzieć, że populacja składa się z dwóch odrębnych części: myszy osiadłych o stałym tempie ubywania z powierzchni, oraz myszy efemerycznych, których ubywanie jest znacznie większe.

Osobnej analizie poddana została grupa myszy efemerycznych. Można spodziewac się, że istnieją myszy osiadłe, które przy zastosowanej metodyce badań będą zarejestrowane jako efemeryczne. Aby ocenić ich ilość przyjęto następujące założenia: myszy osiadłe wśród efemerycznych (tzw. pseudomigranty) posiadają taką samą łowność (średnia ilość złowień w jednostce czasu) jak myszy jawnie osiadłe, łapią się przypadkowo oraz ubywają z powierzchni w tym samym tempie co pozostałe osobniki.

Opierając się na powyższym extrapolowano krzywą długości przebywania co najmniej t tygodni dla myszy jawnie osiadłych, a więc funkcję $N'_t = N_1 \cdot e^{-\mu(t-1)}$ dla $t \geqslant 1$ na punkt $t = 0$ i otrzymano $N'_0 = N_1 \cdot e^{\mu}$.

Otrzymana wielkość jest oceną ilości osobników osiadłych wśród zarejestrowanych. Ilość ta składa się z myszy jawnie osiadłych oraz osiadłych wśród efemerycznych (pseudomigranty). Oceną tych ostatnich jest wielkość:

$$N_p = N'_o - N_1 = N_1\,(e^{\mu} - 1)$$

Pozostałe myszy w populacji — to migranty (N_m), które tylko przechodzą przez badaną powierzchnię (tab. VIII). W badanych populacjach migranty stanowią wysoki procent wśród myszy efemerycznych (dla strychu 75%, dla domu 85%). Obliczono wskaźniki osiadłości i migracyjności (tab. IX). Jako wskaźniki osiadłości przyjęto udział osiadłych wśród zarejestrowanych (d_1). Pewnym wskaźnikiem osiadłości jest także udział pseudomigrantów wśród efemerycznych (d_2). Wskaźniki migracyjności są uzupełnieniem do jedności wskaźników osiadłości. Wprowadzono ponadto trzeci wskaźnik migracyjności jako udział migrantów wśród osiadłych (d'_3) (tab. IX).

ADDRESSES OF THE AUTHORES:

Mgr. Teresa Wierzbowska,
Prof. Kazimierz Petrusewicz
Institute of Ecology Warszawa,
ul. Nowy Świat 72, Poland.