KOMITET EKOLOGICZNY - POLSKA AKADEMIA NAUK

EKOLOGIA POLSKA - SERIA A

Tom XII Warszawa 1964 Nr 18

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RATE OF ABSORPTION OF NEWCOMERS BY A CONFINED WHITE MOUSE POPULATION*

Constant numbers of newcomers, although varying numbers to different populations, were introduced to white mice populations. It was observed that various processes — the decrease in mortality to normal among the newcomers, the occupation of the nests, as well as differentiation among newcomers as a result of fight victories — occur at somewhat different time and are not synchronized between populations. It looks as if the absorption of mice by a population takes place gradually, the newcomers becoming a part of the population after 3—5 weeks.

This paper is an expansion and completion of the work of Andrzejewski, Petrusewicz and Walkowa (1963). From this paper we know that the part of introduced mice remained alive to the end of the experiment (20 weeks), living beside and with the pre-existing population members (referred to hereafter as residents); this indicates they were in some way assimilated into the population. It was assumed this work that newcomers added to a pre-existing population are accepted after one month, that is, they become a composite element of population.

The purpose of this work was to investigate how soon newcomers assimilate into a population and if the process of assimilation proceeds gradually through a certain period of time or occurs suddenly, especially if the rate of assimilation is measured by various processes (indexes) confirming absorption by the population.

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1. METHODS

The experiment is based on the same material as the above cited paper and for this reason an explanation of the methods used will be given only briefly.

Three groups of white mice (*H* 10, *H* 11, *H* 12) including 20 females and 20 males each were placed in three isolated pens 5.7 m² situated indoors. Food and water, always present in excess, were placed in the center of the pens. Nest-boxes served as places of cover and were located on eight ledges hanging on the wall in each pen. There was separate access to each ledge by wire netting.

Four weeks after placement of the population in the pens, newcomers were added to the populations every four weeks:

to population *H* 12 – 8 ♂♂ and 8 ♀♀
H 11 – 4 ♂♂ and 4 ♀♀
H 10 – 2 ♂♂ and 2 ♀♀

Five introductions were made to every population; the experiments lasted 24 weeks. Mice used in the experiments were around three months of age. Each mouse was marked by toe clipping, and each male had a conventional, clearly visible mark on its fur.

The following observations were conducted:

1. Four days a week (and six days during weeks of introduction) at nine o'clock in the morning (the time of least activity) the position of each mouse in the pen was recorded. Deaths and births were recorded each day.

2. During the first three days of each week (nine hours of observation weekly) the fights between the males were observed and the winners and losers were noted.

In concluding whether the added mice belonged or did not belong to the populations, certain characterics of the newcomers and residents were considered. The following indicators were used for comparison: 1) mortality, 2) occupation of nest-boxes, 3) fights of the males.

These indicators were chosen because they are to a certain degree a reflection of phenomena play a basic role in the life of populations. Changes in these factors, then, reflect the assimilation of the newcomers into the population.

2. RESULTS

2.1 Mortality of newcomers and residents

The mortality of the newcomers during the first month after an introduction is greater than the mortality of the residents, but mortality of the newcomers

diminishes with an increase in the number of added mice (Andrzejewski, Petrusewicz and Walkowa 1963).

The mortality of newcomers and residents in the successive weeks after introduction were compared.

Since five additions were made, it was possible to observe the mice introduced in the first week for 20 weeks, those from the second addition 16 weeks, etc.; newcomers from the last introduction were observed only four weeks. The mortality index, consisting of the ratio of dead mice in subsequent weeks after their introduction, to the number of newcomers surviving a giving time after introduction: those surviving one week, those surviving two weeks etc., up to 20 weeks, was calculated and totaled from the indexes recorded for each introduction, but was figured separately for each population.

A comparison of the mortality of the newcomers and residents was made using the statistic χ^2 according to the following formula:

$$\chi^2 = \sum_{i=1}^{r} \frac{n_i \cdot n_i^1 (n_i + n_i^1)}{(d_i + d_i^1)(n_i + n_i^1 - d_i - d_i^1)} \cdot \left(\frac{d_i}{n_i} - \frac{d_i^1}{n_i^1} \right)^2$$

when r – number of weeks

n_i – number of residents

n_i^1 – number of newcomers

d_i – resident deaths

d_i^1 – newcomer deaths

$\frac{d_i}{n_i}$ – index of resident mortality

$\frac{d_i^1}{n_i^1}$ – index of newcomer mortality

The significance of differences between the mortality of newcomers and residents was on the 0.05 level for 1 degree of freedom $\chi^2_{0.05} = 3.841$. A comparison of values (Fig. 1) shows that shortly after an addition of newcomers to a population, empirical χ^2 is greater than $\chi^2_{0.05}$ (*H* 12 in the third week, *H* 11 in the second and third weeks, *H* 10 in the second week), this means that differences in the mortality of residents and newcomers are significant. Mortality is higher among newcomers than among residents. Than after the fourth week in populations *H* 12 and *H* 11, and after the third week in *H* 10 χ^2 is less than $\chi^2_{0.05}$. This allows us to divide the time spent by newcomers in the population into two periods. The first period includes the

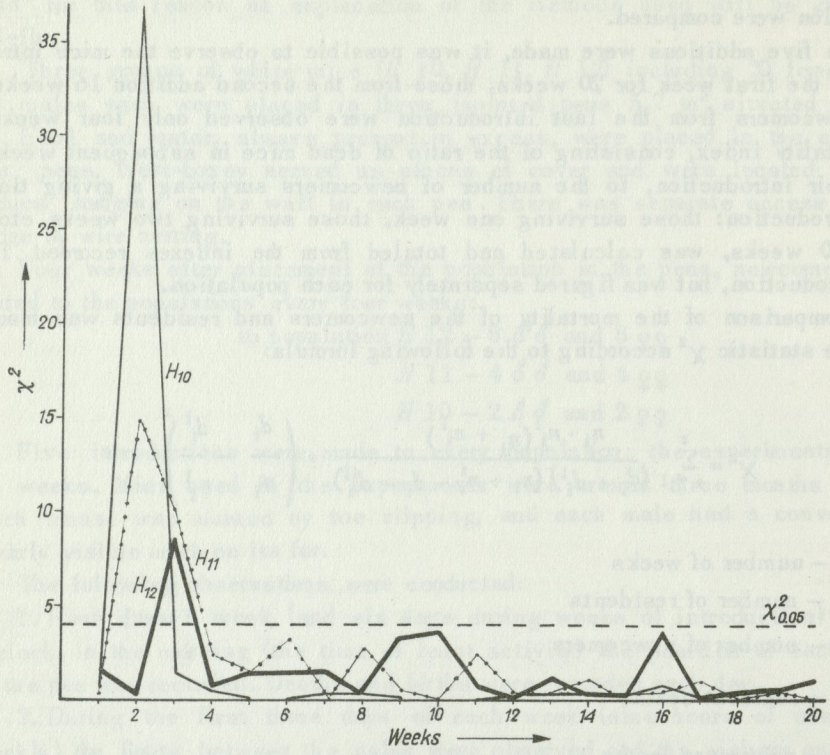

Fig. 1 Theoretical and empirical value of χ^2 during consecutive span of time in the investigation of newcomer and resident mortality

Time axis for newcomers – weeks of their life in the population, independent of their introduction, for residents-weeks from first introduction

beginning three weeks and the second the remaining time. In order to increase the accuracy of the reason the number of freedom degrees (r) was increased, that is, a larger number of tests were taken.

The mortality of the newcomers and residents was compared during the first and second periods.

The values of χ^2 for the three weeks immediately following an addition are as follows:

$H\ 10 = 39.826$
$H\ 11 = 24.351$ $\chi^2 = 7.815$
$H\ 12 = 10.379$ for 3 degrees of freedom

The values of χ^2 for the second three weeks are:

H 10 = 3.538
H 11 = 15.858 $\chi^2 = 27.587$
H 12 = 20.672 for 17 degrees of freedom

The above data indicate the mortality of newcomers which have been in the population less than four weeks is significantly higher than that of residents; whereas newcomers which have already survived four weeks in the population do not differ significantly from residents in a comparison of mortality rates.

Andrzejewski, Petrusewicz and Walkowa found that during the first month after introduction the mortality of the newcomers is influenced to a large degree by the number of individuals introduced, i.e. the more individuals added the lower their mortality is.

It also appears that during a later part of the newcomers stay in a population the number of mice added is of some importance. Although the differences of mortality rates of residents and newcomers already living in the population four weeks not statistically significant, nevertheless the values of resemblance between them are dependent on the number of added mice. This is shown by the rising value of χ^2; the smaller the stimulus, the greater the similarity $(\chi^2 \leqslant \chi^2_{0.05})$.

It seems that the time from addition to appearance of an increase in mortality among newcomers also depends on the number of newcomers. In the case of population H 12 (Fig. 1) where there was the largest number of introduced mice, a difference between the mortality of newcomers and residents appeared latest. In population H 10, where the smallest number of mice were introduced, this difference appeared earliest.

2.2 Occupation of nest boxes

The extent of settlement in the nest boxes is to a certain degree a reflection of the familiarity of the individuals with the terrain and nest boxes, the tolerance of the residents for the newcomers, or in other words is a fair indication of his absorption by the population.

The settlement of the nest boxes by the newcomers was investigated. The per cent of the total residents in the nest boxes in a certain week was observed, as well as the per cent of the newcomers in the nest boxes during the day. When figuring the per cent of the newcomers in the nest boxes, mice from all introductions which had lived the same number of weeks in the population were counted. Since 5 introductions were made (an introduction every 4th week), when calculating the per cent of the newcomers in the nest boxes for the 1, 2, 3, 4 weeks, data from all five introduction was used (since after the last introduction, observation lasted four weeks), for the 5, 6, 7, 8 weeks data from 4 introductions was used (excluding the 5th introduction), for the 9, 10, 11, 12

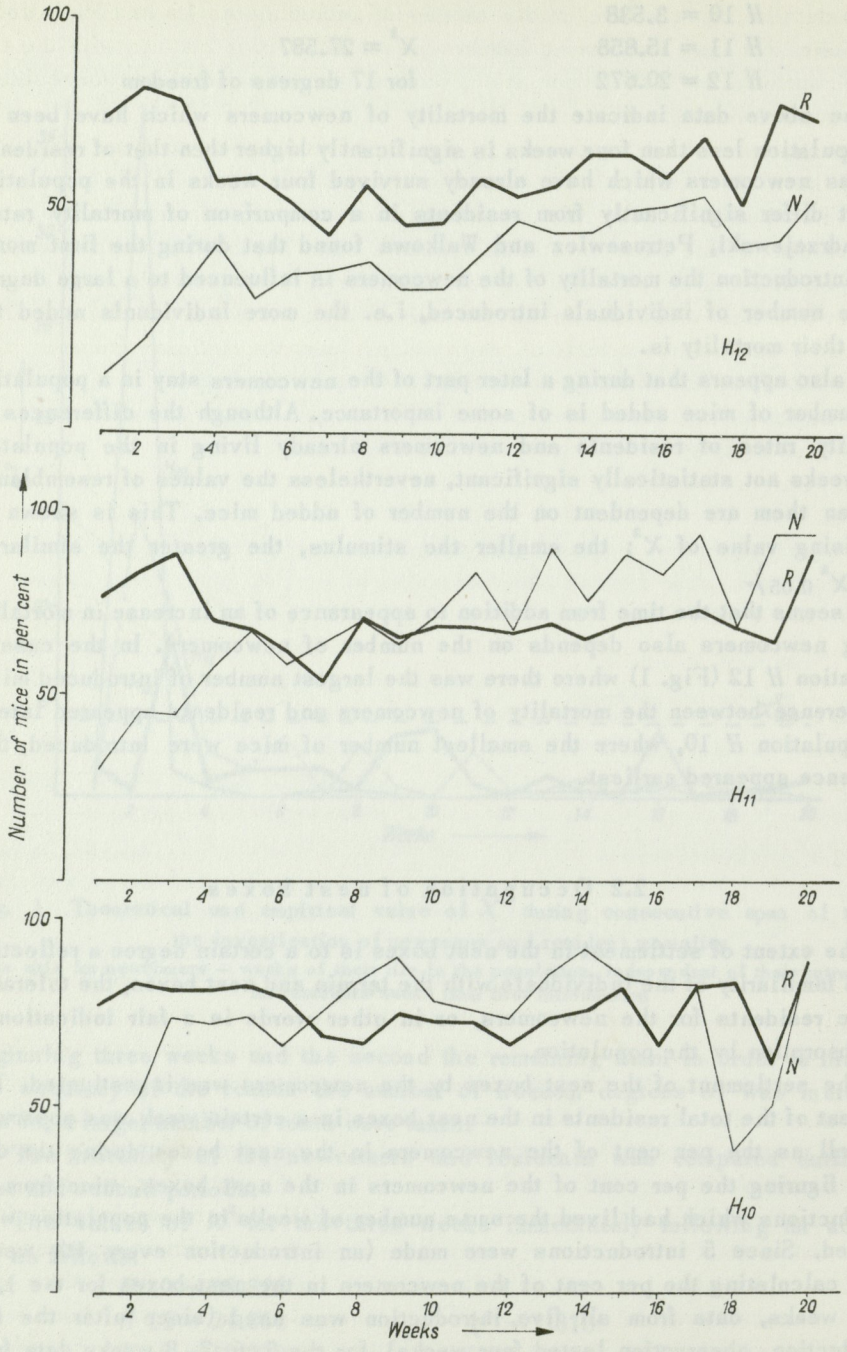

Fig. 2 Occupation of nest boxes by residents and newcomers (% of total number in each group). Time axis as in Fig. 1 R-residents, N-newcomers

weeks data from three introductions was used (excluding the 4th and 5th introductions) etc. The time axis for newcomers presented in Fig. 2 starts with the time of their introduction to the population, whereas the time calculated for residents is the total time of the experiment.

An analysis of the settlement of the nest boxes by newcomers (Fig. 2, 3) shows that:

1. Two periods can be distinguished for newcomers; during the first period the per cent of the mice occupying the nest boxes rapidly increases (for *H* 10 this period is three weeks, for *H* 11 five, for *H* 12 four weeks) and sharply differs from the residents settlement curve; during the second there is little difference between the trends of the residents curve and the newcomers curve.

2. The smaller the number of newcomers, the sooner the newcomers occupy the nest boxes during the first period. During the second period, in population *H* 10 where the smallest number of mice was introduced, the per cent of newcomers in the nest boxes was even larger than the per cent of residents. In population *H* 12 where the largest number of mice was introduced, the per cent of newcomers occupying the nest boxes is smaller than the per cent of residents.

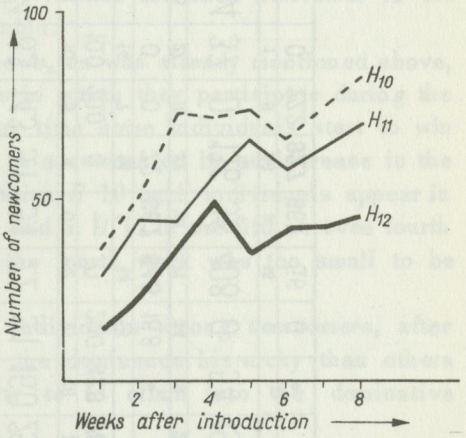

Fig. 3 Per cent of newcomers occupying nest boxes

2.3 Fights of the males

As was found by Andrzejewski, Petrusewicz and Walkowa, there is an increase in the fighting among the mice immediately following an introduction. The fights take place mainly between residents and newcomers. It was found that the added mice: (1) are assimilated into the population to a certain degree during the second week (this is shown by the fact that two to four weeks after the introduction, fighting between residents and newcomers is considerably less than during the first week); (2) occupy the lowest positions in the domination hierarchy (they are defeated in almost 100% of the fights occuring).

Regardless of the high number of fights in which the newcomers participate, they lose almost 100% of the fights occuring. As the experiment progresses the fight results begin to be more differenciated for the newcomers. Mice which show tendencies toward winning fights start to appear. In order to observe more closely this process, the mice were divided into two groups.

The first group included every male which won less than 50% of fights as

Tab. I

Per cent of fights won by newcomers of total number of their fights

Population	Males		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
H.12	Newcomers without ♂♂ 40,39,60	n	367	134	191	139	51	65	123	76	70	48	92	96	39	22	23	13	8	5	9	8
		%	2.7	12.0	4.2	18.7	13.7	9.2	21.1	30.3	27.2	16.7	33.7	36.5	33.3	**54.5**	**52.2**	15.4	37.5	20.0	44.4	**75.0** •
	♂40	n	42	25	33	8	34	36	57	44	31	13	8	8								
		%	11.9	0	36.4	37.8	26.5	**83.9**	**77.2**	**84.1**	**74.2**	30.8	**62.5**	12.5	+							
	♂39	n	11	8	4	5	8	14	15	28	12	28	29	13	15							
		%	18.2	0	0	**60.0**	25.0	14.3	13.3	3.6	8.3	**85.7**	**93.1**	**61.5**	**86.7**	+						
	♂60	n	5	6	7	12	57	10	18	16	7	0										
		%	0	0	0	0	**73.7**	10.0	33.3	**93.7**	42.9	–	•									
H.11	Newcomers without ♂♂ 43,59	n	365	70	145	56	22	44	28	33	25	31	6	11	7	0	17	7				
		%	1.1	11.4	8.3	14.3	9.1	9.1	7.2	9.1	16.0	29.0	50.0	**54.6**	42.9	–	29.4	0	•			
	♂43	n	33	31	10	5	4	0	2	10	28	32	17	29								
		%	0	0	10.0	20.0	0	–	0	20.0	42.9	**78.1**	**58.8**	**79.3**	•							
	♂59	n	13	7	14	7	14	9	14	16												
		%	0	0	0	0	7.2	**66.7**	**64.3**	18.8	•											
H.10	Newcomers without ♂ 53	n	415	65	27	15	22	28	71	34	19	26	21	31	13	3	6	2				
		%	3.9	15.4	3.7	0	13.6	3.6	40.8	0	5.4	19.2	42.9	6.5	7.7	0	0	0	•			
	♂53	n	38	9	1	9	96	9	18	2												
		%	2.6	0	0	22.2	**92.7**	**66.7**	5.6	0	•											

n – number of fights observed, % – per cent of fights won, + – death, • – end of experiment, – – no fights.

well as each which won more than 50% in only one week if the number of fights participated in was less than 10 (Tab. I). This group was considered as a unit, that is, the per cent fights won by all members was calculated in relation to the total number of fights in which the group participated. The decrease in the number of fights as the experiment progresses is partly a result of the decreasing number of newcomers in the population (members of the fifth introduction were in the population four weeks, members of the fourth, eight weeks, etc., so that only members of the first introduction had a chance to survive 20 weeks).

The second group included males which won more than 50% of their fights in two or more consecutive weeks regardless of the number of fights participated in, or those which participated in more than 10 fight and won more than 50% of their fight during one week. The fight results for each newcomer in the second group are given separately in the table.

An analysis of the results (Tab. I) shows, as was already mentioned above, that all newcomers lose almost all fights in which they participate during the first weeks in a population. After a some time some individuals start to win more fights than they lose; this usually is accompanied by an increase in the number of their fights (Tab. I). In population *H* 10 such individuals appear in the fifth week, in *H* 11 in the sixth week, and in *H* 12 in the fifth or even fourth week (although the number of fights in the fourth week was too small to be significant).

The above data show that certain individuals among newcomers, after a certain time find a higher position in the dominance hierarchy than others newcomers, which indicates their ability to to climb into the dominative hierarchy.

CONCLUSION

On the basis of the above described materials we can suppose that the absorption of mice by a population is gradual, and various processes indicating the assimilation of the newcomers into the population take place at different times and are not synchronized between populations.

1. The number of fights between newcomers and residents after one week is less than would be probable. After the first week, the frequency of fights generally decreases. This indicates that the newcomers are to a certain degree assimilated into the population, occupying the lowest position in the domination hierarchy (Andrzejewski, Petrusewicz and Walkowa 1963).

2. The return of the newcomers mortality rate to normal, that is, the resemblance to the mortality level of the residents takes place later: for *H* 12 in the fourth week, for *H* 11 in the fourth week, and for *H* 10 in the third week.

3. The *H* 12 population occupies the nests in the fourth week, *H* 11 in the fifth week, *H* 10 in the third week.

4. The division of newcomers into those often fighting and seldom fighting, those losing and those winning, (as these divisions can be noted with residents) can be done in the case of *H* 12 from the fifth week on, for *H* 11 from the sixth week, for *H* 10 from the fifth week.

The above results indicate that considering such factors as mortality of the mice, the occupation of the nest boxes, and differences between males as regards victories in fights, 3–5 weeks after the introduction of newcomers they can be considered accepted by the population.

REFERENCES

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TEMPO WŁĄCZANIA SIĘ INTRODUKOWANYCH OSOBNIKÓW DO ZAMKNIĘTEJ POPULACJI BIAŁYCH MYSZY

Streszczenie

Do populacji białych myszy (*H* 10, *H* 11, *H* 12), hodowanych w zamkniętych zagrodach o powierzchni 5,7 m² każda, introdukowano co 4 tygodnie obce osobniki:

do populacji *H* 12 po 8 ♂♂ i 8 ♀♀
H 11 po 4 ♂♂ i 4 ♀♀
H 10 po 2 ♂♂ i 2 ♀♀

Dokonano 5 introdukcji do każdej populacji.

Wszystkie myszy znakowano indywidualnymi numerami przy pomocy amputacji palców łap oraz każdy samiec miał swój znak na sierści z daleka rozpoznawalny.

Pokarm i wodę podawano w nadmiarze.

Wnioskowanie o włączeniu się lub nie włączeniu się do populacji osobników introdukowanych oparto na porównaniu wskaźników śmiertelności, opanowywaniu domków gniazdowych oraz walk samców z populacji i obcych.

1. Po wpuszczeniu śmiertelność introdukowanych myszy jest większa od śmiertelności myszy z populacji. Śmiertelność myszy introdukowanych i myszy z populacji porównano przy pomocy statystyki χ^2. W początkowym okresie po wpuszczeniu śmiertelność osobników wpuszczonych istotnie różni się od śmiertelności osobników populacji (dla *H* 12 w 3 tyg., *H* 11 w 2–3 tyg., *H* 10 w 2 tyg.) natomiast u tych, które przeżyły już 3–4 tygodnie w populacji, nie ma istotnej różnicy w śmiertelności (Fig. 1). Wydaje się, że podobieństwo wskaźników śmiertelności omawianych kategorii osobników zależy od liczby wpuszczonych myszy; im była ona mniejsza, tym większe było podobieństwo.

2. Przy opanowywaniu domków gniazdowych przez myszy wpuszczone można wyróżnić 2 okresy (Fig. 2): początkowy, gdzie procent myszy zajmujących domki gniazdowe szybko wzrasta (dla *H* 10 do 3-go tyg., *H* 11 do 5-go tyg., *H* 12 do 4-go tyg.) i znacznie odbiega od krzywej zasiedlenia myszy z populacji i następny, gdzie nie ma prawidłowej dużej rozbieżności w przebiegu tej krzywej w porównaniu z krzywą dla myszy z populacji.

3. Wszystkie introdukowane myszy w początkowym okresie po wpuszczeniu przegrywają prawie wszystkie walki (Tab. I). Z biegiem czasu występuje wśród nich zróżnicowanie pod względem zwycięstw w walkach, tak jak to jest u myszy z populacji. Wyróżniają się osobniki, wygrywające powyżej 50% toczonych walk (dla *H* 12 od 5-go tyg., *H* 11 od 6-go tyg., *H* 10 od 5-go tyg.).

Na podstawie wyżej wymienionych danych można przypuszczać, że włączanie się introdukowanych myszy do zamkniętych populacji przebiega stopniowo i w różnych populacjach asynchronicznie.

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