Lech RYSZKOWSKI & Janusz TRUSZKOWSKI

Survival of Unweaned and Juvenile Bank Voles under Field Conditions

[With 3 Figs. & 4 Tables]

The nest boxes were applied to study natality and survival of unweaned and juvenile individuals in a *Clethrionomys glareolus* (Schreber, 1780) population. The nest boxes were used by bank voles as feeding posts, places in which food was stored, places to build nests as well as places to have young. The average litter size found in the nest boxes was 4.8. The drop in litter size as well as a restriction of breeding to part of the habitat was found during the course of the year. A total of 404 newborn bank voles were marked during the whole breeding season. In three distinguishable cohorts of newborn animals survival from birth till animals were trappable in live traps amouted from 47 to 61 per cent.

1. INTRODUCTION, METHODS AND STUDY AREAS

There are very little published data pertinent to survival of unweaned and juvenile rodents under field conditions. The most suitable technique for studying this survival is perhaps the use of nest boxes. The nest box technique for studying ground living rodents was first designed by Nicholson (1941). These nest boxes were employed successfully for studies on dispersal and longevity of *Peromyscus maniculatus bairdii* (Hoy & Kennicot, 1857) by Howard (1949).

In the studies reported here the nest boxes were used to observe the survival of unweaned and juvenile bank voles *Clethrionomys glareolus* (Schreber, 1780).

The nest boxes were constructed from wood and consisted of a protective outside box within which were a proper nest chamber and a trapping device. The entrance to the nest chamber was fastened to the trapping device through which the rodents must pass after entering the nest box through a tunnel which opened outside of the nest box. Between the nest chamber and protective box a free air space was

left in order to provide insulation. The nest boxes were buried in the ground so that the tops were level with the ground, and could still be opened because they were fastened to the rest of the protective box by hinges. The outside of the top was covered by tar-paper. The tunnel entrance was also on the level of the ground. The measurements of the nest box are shown in Fig. 1.

The studies were carried on in the forest near the Field Station of the Institute of Ecology at Dziekanów Leśny near Warsaw and on the island situated in Lake Bełdany (Mazurian lake district). The forest at Dziekanów Leśny consists of the following associations: *Pino-Quercetum, Vaccinio myrtilli-Pinetum* and *Carici elon-gate-Alnetum* (T r a c z y k & T r a c z y k, 1965). The island is covered by four phytosociological associations: *Tilio-Carpinetum typicum, Tilio-Carpinetum stachyeto-sum silvaticae, Circeo-Alnetum* and *Salici-Franguletum* (T r a c z y k, 1965).

Forty nest boxes were unevenly distributed on an area of 2.2 ha at Dziekanów. The locations were chosen because it was estimated that these places were most likely to be frequented by rodents. These places were in the vicinity of rotten stumps, clumps of sedge, fallen trees and so on. It was observed that nest boxes were spaced not closer then 20 meters each from the others.
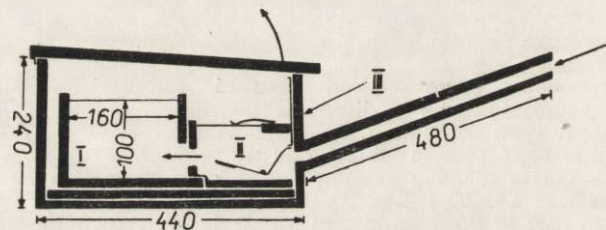

Fig. 1. Cross-section of nest box.
I — Nest chamber, II — Trapping device, III — Protective box. All measurements shown in milimeters.

The studies in Dziekanów forest were carried out from April till October 1967. The nest boxes were inspected irregularly according to different schemes of observation of rodent activity in the nest boxes. Animals, including new-born ones trapped in the nest boxes were marked individually by toe clipping.

On the four hectare island nest boxes were distributed in a grid pattern spaced 30 meters by 30 meters apart. The period of studies extended from March 1968 till October 1968. The nest boxes were checked approximatly every two weeks. Two systems of marking by toe clipping were used: individual marking and group marking. Simultaneously with the use of the nest boxes the rodents were caught in live traps in order to obtain estimates of population dynamics. This programme was carried on by Dr. R. Andrzejewski and his team. The authors acknowledge his permission to use data from the live trapings.

2. RESULTS

2.1. The Use of Nest Boxes by Rodents.

The nest box could be a good tool to study the rodent population if the rodents use it to fullfill their day to day activities. Any behavioural restrictions of rodents towards nest boxes invalidates their successful

application. The following types of rodent activity in order of increasing complexity connected with the use of nest boxes were distinguished: (a) use of the nest box as a feeding post, (b) storing of food in the nest box, (c) construction of nest, (d) offspring bearing and raising.

Into 40 buried nest boxes in the Dziekanów forest a few oat grains were put and on the following consecutive days observations were made to see if the grains were eaten. After 24-hours in almost 80 percent of the nest boxes the food was taken and by the third day all nest boxes were visited (Fig. 2). Such results support the conclusion that nest boxes are frequented by rodents very often.
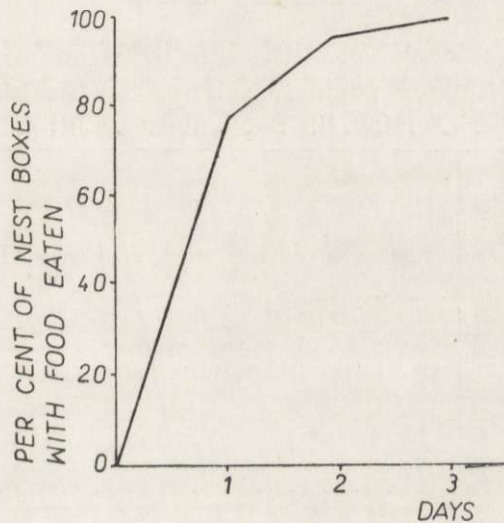

Fig. 2. Use of the nest box as a feeding post.

The food stored in nest boxes consisted of the following items: a) plants, including acorns, hazelnuts (*Corylus avellana* L.), pine cornes (*Pinus silvestris* L.), rowan seeds (*Sorbus aucuparia* L.) blades of grass and green fresh parts of plants; b) animals including parts of insects (more often of pupae then imago) and parts of snail shells (*Corneus* sp.).

The storing activity of rodents recorded in the nest boxes increased rapidly at the end of summer (Fig. 3) which matches well with the biology of rodents.

During the studies carried on in the Dziekanów forest all together 25 nests were constructed in the nest boxes. According to prior studies done by J. Truszkowski (to be published elsewhere) it was possible to classify them as made by *C. glareolus* and *A. flavicollis*. After one month of use

about 60 percent of the nests were abandoned. About 20 percent of the nests were used for a period of four or five months.

In eight of the nest boxes females gave birth to young. Four litters of *C. glareolus* and four of *A. flavicollis* were observed.

It seems that nest boxes are used quite successfully by rodents. Nevertheless the degree of preference of nest boxes in reference to natural shelters is still unknown. But, even not knowing the degree of preference one can conclude from the data reported above, that nest boxes can be a suitable tool to study populations of rodents.

2.2. Litter Size

The estimation of bank vole litter size by means of nest boxes was carried out on an isolated population living on an island. During the whole breeding period (May till September) 84 litters were observed.
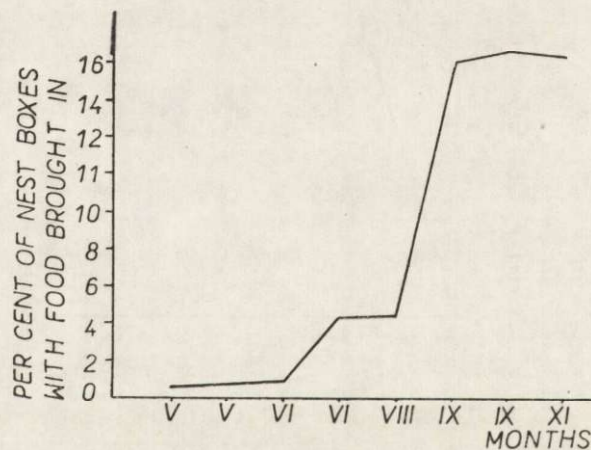

Fig. 3. Storing activity of rodents.

The mean litter size was 4.6 ± 0.18. For the 55 litters observed during May and June the mean size 5.3 ± 0.23 and for 29 found in July, August and September mean litter size was 3.9 ± 0.22. The difference is statistically significant ($t = 4.1$; $P < 0.01$). The sharp drop in litter size was in late summer.

2.3. Distribution of Litters

The area of each plant association distinguished on the island was roughly reflected by the number of nest boxes placed in each habitat (Table 1). The largest area of the island was covered by *Tilio-Carpinetum*

typicum (*TC*), and the second by *Tilio-Carpinetum stachyetosum silvaticae* (*TCs*). For both of these habitats it was possible to carry on a more detailed analysis of distribution of litters.

The average number of litters per nest box in May and June was similar for *TC* and *TCs* (Table 1). The difference is not statistically significant. Later in the year a sharp drop of litter numbers was observed in *TCs* in contrast to *TC* where the decrease was not so evident (Table 1). Of the total number of litters (50) found in *TC*, 46 percent were observed

Table 1.

Distribution of litters in different habitats.

Habitat	Number of:			Average number of litters per nest box	
	nest boxes	litters		May June	July, Aug. Sept.
		May, June	July, Aug. Sept.		
Tilio-Carpinetum typicum	37	27	23	0.72	0.62
Tilio-Carpinetum stachyetosum silvaticae	19	16	2	0.84	0.10
Circaeo-Alnetum	7	6	2	—	—
Salici-Franguletum	6	2	2	—	—

Table 2.

Distribution of litters in *Tilio-Carpinetum typicum* forest.

Period	Mean $(\bar{x})$	Variance $(\bar{\sigma}^2)$	$\sigma^2 : \bar{x}$	Statistical significance discrepancy from random distribution
May, June	0.72	1.05	1.33	$p > 0.05$
July, August, September	0.62	0.66	1.06	$p > 0.05$
Whole span of breeding	1.34	2.99	2.23	$p < 0.01$

in July, August and September but in *TCs* only 11 percent of 18 litters were found in the same period. The difference is statistically significant ($P < 0.001$). One can conclude that breeding was much more restricted to *TC* than to *TCs* in late summer and fall.

The average litter size for *TC* in May and June was 5.0 young and in July, August and September was 4.0. The difference is statistically significant ($P < 0.01$). The intensity of breeding decreased in late summer

and fall even in *Tilio-Carpinetum typicum*. For May and June the litter size was similar in *TC* (5.0 young) and *TCs* (5.4 young). The difference is not statistically significant.

In order to find if litters were distributed randomly within the *TC* habitat, the variance of litters per nest box was compared with its mean. In a Poisson distribution variance (o^2) is equal to the mean ($\bar{x}$), therefore when the ratio of the variance to the mean is greater then one it indicates clumped distribution. A statistically significant difference from one can be checked by a *t*-test (G r e i g - S m i t h, 1964) according to the following formula:

$$t = [(o^2 : \bar{x}) - 1] : S;$$

where $S = \sqrt{2 : (N-1)}$ and N = the number of samples- for $N-1$ degrees of freedom. When the analysis of distribution of litters in next boxes was carried out for May and June separately from July, August and September random distributions were found in both periods. The analysis for the whole breeding period showed a clumped distribution (Table 2), which indicated that some nest boxes were used by bank voles for breeding more often then others during the whole breeding season. During the whole breeding season the largest number of litters observed in one nest box was seven. The reason for the frequent selection of certain nest boxes is unknown.

2.4. Survival of Unweaned and Juvenile Bank Voles

A total of 404 newborn bank voles were marked during the whole breeding season. The age of the animals at the time of marking was distinguished according to criteria given by S v i r i d e n k o (1959). The majority of marked animals were from four to ten days old. A few of the oldest animals were about 14 days old which was determined by the frequency of nest box checkings (each two weeks). The youngest animals observed in nest boxes were one day old.

The analysis of survival was carried on for cohorts of animals, that is, for animals which were born in the period between two checkings of nest boxes. Three such cohorts which were abundant enough to permit calculations were distinguished (Table 3). The number of surviving bank voles was estimated by live trappings which were carried on for ten days each forty days. The number of animals present during each census was estimated according the method of calendar of captures (P e t r u s e - w i c z & A n d r z e j e w s k i, 1962). As the result of the different periods separating nest-box and live trap censuses there were various length time intervals for which survival of each cohort was calculated. If the

live trapping census was carried on immediately after the nest box census the survival time was calculated to the next trapping census to be sure that all animals left the nests.

Table 3.

Cohort survival.

Date of cohort marking	Number born	Number surviving	Percent surviving	Time interval in days	Instantaneous mortality rate (μ)
May 7—8	62	38	61	32	0.015
June 11—12	112	63	56	59	0.009
May 22—24	67	32	47	39	0.019

Table 4.

Number of voles surviving from litters of various size.

		Litter size							
	1	2	3	4	5	6	7	8	9
0	1	1	1	2	1				
1			2			2	1		
2		1		1	1	1			
3				4	1				
4				1		1			
5					2	2	1		
6						1	1		
7							3		
8									1

(Row label, left vertical: Number of surviving voles)

In order to compare the results obtained for various cohorts the instantaneous mortality rate was calculated from the following equation:

$$N_t = N_o e{-\mu t}$$

where N_o — initial number of animals in cohort,
N_t — number of survival individuals up to time t,
e — base of natural logarithms,
μ — instantaneous mortality rate.

The second cohort which was marked on May 22—24 had the lowest mortality rate (Table 3). Because for this cohort the interval of time

separating marking from live trap censusing was also the longest, one can conclude that the mortality was really the lowest and was not the result of the length of time used in the calculations.

For the first cohort which was marked two weeks earlier as well as for the third cohort marked two weeks later then the second cohort the mortality rates were almost twofold higher.

Using only those animals which had similar survival times a correlation was calculated between the size of the litter and the number surviving to first capture in live traps (Table 4). The correlation coefficient is 0.9 and is statistically significant ($P < 0.01$). This result is of great importance because the number of animals which will participate in the breeding pool of the next generation is proportional to the litter size of parent individuals.

3. DISCUSSION

The nest box technique proved to be a quite suitable tool to study natality and survival of a bank vole population. It is suprising that nest boxes have not been commonly applied since H o w a r d published his studies in 1949.

The estimate of mean litter size (4.8) obtained here for an island population matches quite well with average litter size of 4.9 reported by B u j a l s k a & R y s z k o w s k i (1966) for the Dziekanów forest. The estimate is also similar to data for lowlands and medium high regions in Czechoslovakia (4.9 — cf. Z e j d a, 1966), and for Germany (4.9 — published by S t e i n, 1950).

In our studies the litter size was calculated for new born animals about 6 days old, in these other studies litter size was estimated from sections of pregnant females. The resemblance of mean litter sizes in these four studies can not be interpreted to mean that there in no difference between the litter size estimated by counting embryos in killed females or counting newborn animals. To show what is the mortality in late pregnancy one has to compare the results obtained by these two methods in the same terrain and season. Nevertheless, as the first approximation one can conclude that survival during late pregnancy and the first days after birth is high.

The restriction of reproduction success during the course of the year was due to two factors: (a) by a decrease of litter size in late summer which was probably connected with the replacement of overwintering females by this years ones (Z e j d a, 1966), (b) by the failure of reproduction in the *Tilio-Carpinetum stachyetosum silvaticae* plant association during late summer. *Tilio-Carpinetum typicum* is similar to *Tilio-Carpi-*

netum stachyetosum silvaticae and the reason of failure of reproduction in this last plant association is unknown.

In the studies reported by H o w a r d (1949) on *P. maniculatus bairdii*, 46 percent of the animals survived up to five weeks of age if data on the whole breeding season are pooled together. If individuals born in spring and summer are considered separately, then only 25 percent of the animals survived up to five weeks of age. In all three of the Bełdany island cohorts (Table 3) survival was much higher then reported by H o w a r d (*l.c.*) for spring and summer generations. On the same island one year earlier the survival during the first 43 days of life was estimated by G l i w i c z *at al.* (1968). The number of newborn animals was indirectly estimated from the known number of pregnant females and mean litter size which was assumed to be similar to Z e j d a's (1966) studies. Survival was estimated by comparison of the estimated number born with the number of animals caught in live traps. The instantaneous mortality rate was equal to 0.035 and was almost twofold to fourfold higher then that calculated from direct observation of survival by means of nest boxes (Table 3). B o b e k (1969) using a similar method of estimation as G l i w i c z *et al.* (1968) calculated the survival rate of a bank vole population in beech forest during the first month to be equal to 61.5 percent.

So far the estimates obtained for survival from birth till animals are prone to traps indicate great variability. For this reason the estimates of population production can be seriously obscured if one can not make proper allowance for the survival of unweaned and juvenile individuals.

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Lech RYSZKOWSKI i Janusz TRUSZKOWSKI

PRZEŻYWALNOŚĆ MŁODYCH NORNIC W WARUNKACH TERENOWYCH

Streszczenie

Badania prowadzono w lesie położonym w pobliżu Stacji Terenowej Instytutu Ekologii PAN w Dziekanowie Leśnym koło Warszawy oraz na porośniętej lasem wyspie, znajdującej się na jeziorze Bełdany. W Dziekanowie Leśnym w 1967 roku oceniono przydatność skrzynek gniazdowych dla populacyjnych badań nad leśnymi gryzoniami. Czterdzieści skrzynek gniazdowych (Ryc. 1) zakopano w ziemi tak, że pokrywa skrzynki i wejście do tunelu znajdowały się na poziomie gruntu. Gryzonie często odwiedzają skrzynki o czym świadczą obserwacje, że w ciągu trzech dni została wyjedzona przynęta ze wszystkich skrzynek (Ryc. 2).

W pokarmie wnoszonym przez gryzonie do skrzynek znajdowano: żołędzie, orzechy leszczyny, nasiona jarzębiny, szyszki sosny i świeże, zielone części roślin, a wśród nich szczególnie często — liście *Oxalis acetosella*, znajdowano również szczątki pochodzenia zwierzęcego, jak części poczwarek, dorosłych owadów i muszli ślimaków (*Corneus* sp.). W sierpniu wnoszenie pokarmów do skrzynek wyraźnie zwiększało się (Ryc. 3).

Ogółem w czasie sezonu rozrodczego na wyspie na jeziorze Bełdany zaobserwowano w skrzynkach 84 mioty nornic. Średnia wielkość miotu wynosiła 4,8 ± 0,18 osobnika. W porównaniu do wiosny, latem i wczesną jesienią zaobserwowano ograniczenie rozrodu tylko do części terenu wyspy (Tabela 1), gdzie zaznaczył się jednak wyraźny spadek wielkości miotu.

Skrzynki nie były równomiernie wykorzystywane dla rozrodu przez nornice (Tabela 2). W jednej ze skrzynek zaobserwowano siedem miotów co stanowiło maksimum wykorzystania skrzynek dla rozrodu w całym okresie badań. Wyróżniono trzy kohorty młodych nornic, których przeżywalność do momentu gdy były poławiane w pułapki żywołowne wynosiła od 47 do 61 procent (Tabela 3). Stwierdzono, że im większy miot tym więcej osobników przeżywa (Tabela 4).