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

VOL. XVII, 34: 455—465. BIAŁOWIEŻA December, 1972

Maria MAZURKIEWICZ

Density and Weight Structure of Populations of the Bank Vole in Open and Enclosed Areas

[With 3 Tables & 5 Figs.]

The material analysed was obtainted during the period from 1966—1968 from studies of a population inhabiting an island in the Bełdany lake and of a population living in an open area in the Kampinos National Park during the period from 1970—1971. Comparison of variations in numbers, the growth rate of individuals of the two populations, showed that the isolated population may attain earlier and greater density (during peak years) than the unrestricted population. The growth rate of individuals in the unrestricted population is more rapid than in the isolated population and in consequence the weight structure of newly-marked individuals in the open population corresponds to the structure of individuals about 1.5 months older in the isolated population.

1. INTRODUCTION

Long-term studies of a population of *Clethrionomys glareolus* (Schreber, 1780) living on an island, and thus not exhibiting the phenomena of migration, permitted of ascertaining the course taken by certain population processes such as exact variations in numbers, participation of the cohorts distinguished in variations in numbers, their mortality and participation in reproduction (Bujalska *et al.*, 1968; Bujalska, 1970; Gliwicz *et al.*, 1968; Petrusewicz *et al.*, 1971) and also individual growth rate (Bujalska & Gliwicz, 1968) and its dependence on maturation rate (Bujalska & Gliwicz, 1972). The question next arises as to whether the regularities found can fully apply to a population living in an open space, and primarily, what effect does the possibility of migration exert on the indivduals forming a population.

In the present study comparison has been made of data obtained for an isolated and an unrestricted population of *C. glareolus*, such as va-

riations in numbers, weight structure of individuals at the time of their entry into the population and also the growth rate of individuals.

2. STUDY AREA

The isolated population lived on an island 4 ha in extent situated in the Bełdany lake (northern Poland). The island is covered by a tree stand belonging to 4 phytosociological associations (Traczyk, 1965). The coastal, humid belt is covered by the *Salici-Frangulatum* Malc., 1929, association, the central part of the island by *Tilio-Carpinetum typicum* Traczyk, 1962, which in some parts changes into the sub-association *Tilio-Carpinetum stachyetosum silvaticae* and in the wet depressions of the area — *Circeo-Alnetum* Oberdorfer, 1953.

Studies on the unrestricted population were carried out in the Kampinos National Park (Central Poland). The study aera, 6 ha in extent, is covered by a tree stand belonging to 5 phytocenological associations forming a mosaic: *Salici-Frangulatum* and *Carici elongate alnetum* occupy 34% of the area, *Pino-Quercetum* I — 23%, *Pino-Quercutum* II — 24%, *Vaccinio myrtylli-Pinetum molinietosum* — 16%, *Tilio-Carpinetum* — 3% (Traczyk, 1965).

3. METHOD AND MATERIAL

The material analysed was obtained from studies of the island population from 1966—1968 and of the unrestricted population from 1970—1971.

The study area was covered by a square grid of trapping sites (15×15 m) except for the studies carried out in the Kampinos National Park in 1971, when the grid was rectangular (30×15 m). Live-traps were used for catching the animals, employing the Catch-Mark-Release (*CMR*) method for collecting data.

Five trapping series were carried out each year from spring (end of April) to autumn, at monthly intervals. Each of the series lasted 14 days (in 1966, 1967 on the island and in 1971 in the Kampinos National Park) or in 10 days (in 1968 on the island and 1970 in the open forest area). In the Kampinos National Park in 1970 we also carried out, in addition to the basic trapping series corresponding to the studies on the island, continuous trapping on part of the study area (100 traps arranged in a square with sides approx. 185 m long) and several 5—6-day trapping series in winter (Fig. 2).

During the trapping periods the traps were inspected twice daily (morning and evening) and all the individuals caught were marked and released. When caught for the first and subsequent times the number, weight, sex and place of capture were recorded for each individual.

The material obtained consisted of 22,856 captures of 3,028 individuals on the island and 8,198 captures of 1,570 individuals in the open forest area.

4. RESULTS

4.1. Variations in Numbers of the Study Populations

The numbers of the populations were defined by means of the general census method of individuals present in successive trapping series, five times yearly for the island population (Fig. 1), and also in the

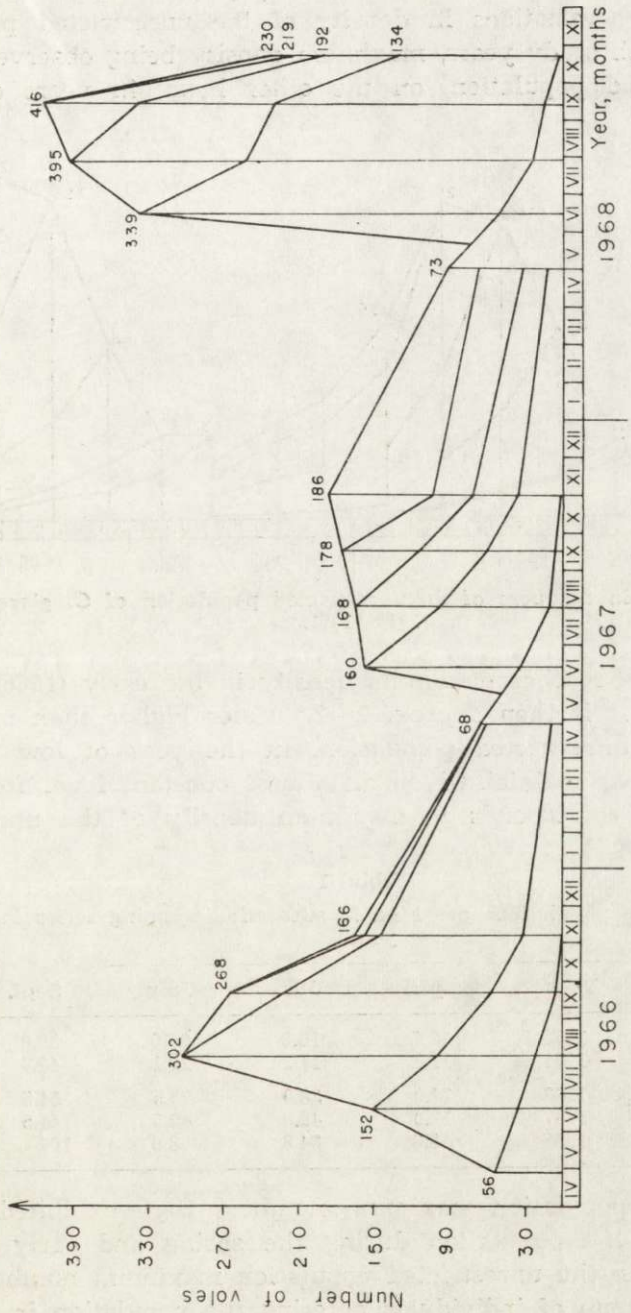

Fig. 1. Variations in numbers of an isolated population of *C glareolus* from 1966—1968 (after Petrusewicz *et al.*, 1971).

winter of 1970/1971 for the open forest population (Fig. 2). Comparison of variations in numbers of the two populations showed that the course taken by variations in density of the unrestricted population is similar in both study years, maximum density being observed in October. The island population, on the other hand, in years of consi-

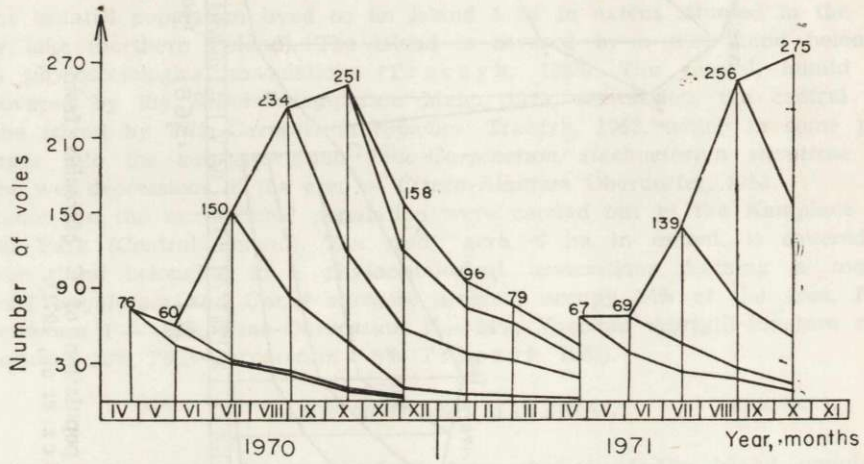

Fig. 2. Variations in numbers of an unrestricted population of *C. glareolus* from 1970—1971.

derable numbers, reaches maximum density in the early (1966) or late summer (1968). It is then approx. 2—2.5 times higher than maximum density of the unrestricted population. In the year of low numbers (1967) density was maintained on an almost constant level from June to October and corresponds to maximum density of the unrestricted population (Table 1).

Table 1

Density of two vole populations per 1 ha in successive trapping series in different years.

	Year	April	June	July	Sept.	Oct.
Forest, open population	1970	12.7	10.0	25.0	39.0	41.8
	1971	11.2	11.2	23.1	42.7	46.0
Island, isolated population	1966	14.0	38.0	75.5	64.5	41.5
	1967	17.0	40.0	42.0	44.5	46.5
	1968	18.3	84.8	98.8	104	57.5

In the island population maximum numbers were exhibited by the cohort entering the population during the spring and early summer period (Fig. 1). In the unrestricted population maximum numbers were found for the group of individuals entering the population in autumn, and peak numbers occur in October (Fig. 2).

4.2. Weight Structure of Newly-marked Individuals

Analysis was made for both populations of the distribution of males' weights at the time of marking and in the subsequent trapping series (that is, about 1.5 months later). Females were omitted from the analysis owing to the considerable variations in their body weight due to pregnancy. The average weight for an individual obtained in a given trapping series was used for calculations. All males entering the po-

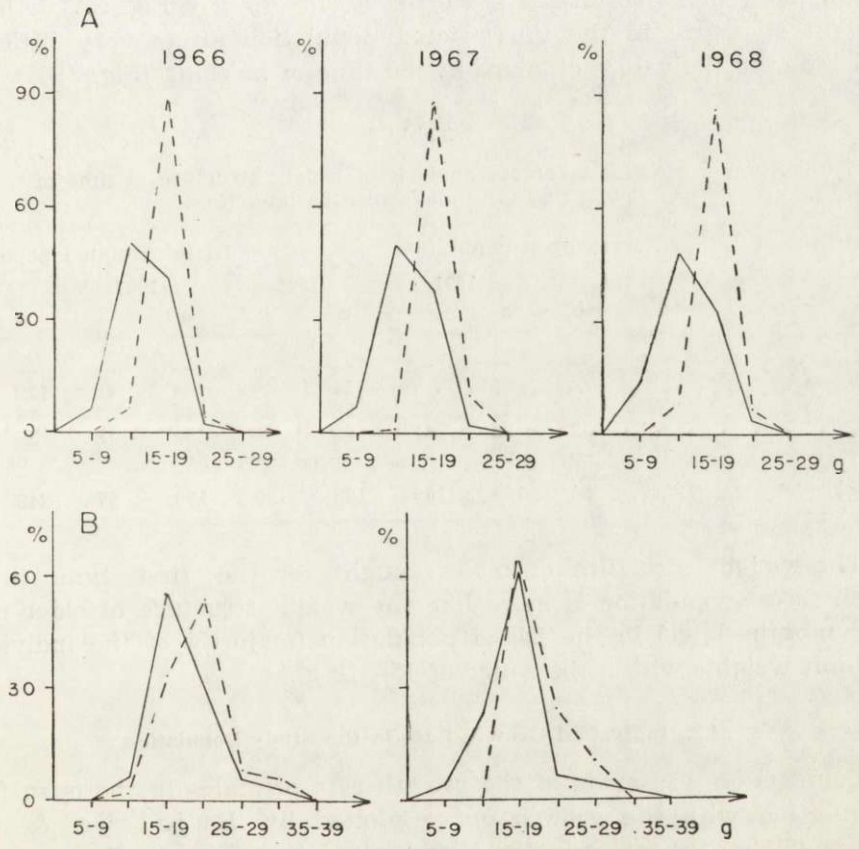

Fig. 3. Weight structure of males in the isolated population (A), and the unrestricted population (B). Continuous line — at time of marking, dotted line — 1.5 months later.

pulation during the reproduction season, excluding old adults, were included in the analysis (Table 2, Fig. 3).

It was found that the weight structure of males caught for the first time in the island population is almost identical in successive study years (Fig. 3A). About 60% of the individuals were marked

when their weight did not exceed 14 g, but in the unrestricted population in the Kampinos National Park only 6% in 1970 and 25% in 1971 were marked at this weight range, and the great majority of the individuals (60%) was marked at weights from 15—19 g (Fig. 3B).

Comparison of the distribution of males' weights at the time of marking with the corresponding distribution for the same individuals 1.5 months later showed that the weight of individuals evens up to a very considerable degree in the island population in all the study years (90% of males attain a weight of 15—19 g — Fig. 3A), whereas weight structure in the unrestricted population alters very little and is similar to the values obtained at the time of marking (Fig. 3B).

Table 2

Number o males taken for analysis of weight structure at time of marking (*a*) and 1.5 months later (*b*).

Month	Forest, open population						Island, isolated population			
	1970		1971		1966		1967		1968	
	a	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*
April	—	—	—	—	—	—	—	—	—	—
June	8	4	9	7	57	39	66	46	129	102
July	57	27	47	37	98	85	40	33	78	55
Sept.	94	32	96	61	23	5	39	18	35	9
Oct.	75	—	67	—	—	—	45	—	6	—
Total	234	64	164	105	188	129	190	97	248	166

The weight structure of males caught for the first time in the open forest population is more like the weight structure of older males (1.5 months later) in the island population (majority of the individuals exhibit weights within the range of 15—19 g).

4.3. Individual Growth Rate in the Study Population

Comparison was made of the growth rate of males in the open forest population with the growth curve plotted by Bujalska & Gliwicz (1968) for males in the island population (Fig. 4). Use was made in this connection of weights of individuals collected in 1970 during regular trapping and also trapping series in part of the study area. In order to render the data uniform the average weight of individuals caught between basic trapping series was calculated for 10-day periods (*i.e.*, the duration of the basic series).

The way in which calculation was made was as follows: a group of the lightest males (9—11 g) was taken and average weight (W_0) and standard deviation (S_0) calculated for them. Then, accepting in turn

$n=0,1, \ldots 8$ on the basis of average weight W_n and deviation S_n, individuals weighing $W_n \pm S_n$ were formed into a group. The average weight of these individuals and standard deviation of this weight 10 days later were taken as W_{n+1}, S_{n+1}. In this way weights $W_0 \ldots W_9$ and deviations $S_0 \ldots S_9$ were obtained (Table 3).

Individuals caught for the first time when weighing 9—11 g are about 26 days old, since they had reached the trappable age (21 days) during a 10-day series, on an average in the middle of the series. This agrees with data given by Bujalska & Gliwicz (1963).

As successive measurements were made at 10-day intervals it may be concluded that the group of individuals with average weight of $W_1=13.4$, $S_1=1.2$ is about 36 days old, and so on, for $n=2.3...9$. This reasoning permitted of defining the relations between age and weight (Fig. 4).

Table 3

Average weight of males (W_n), standard deviation of this weight (S_n) in 10-day intervals (n) and numbers in groups (N).

n	W_n	S_n	N
0	10.2	0.7	19
1	13.4	1.2	34
2	16.1	2.6	43
3	17.8	1.8	103
4	19.0	2.3	69
5	19.9	2.7	82
6	20.5	4.8	52
7	20.8	3.2	43
8	20.9	3.1	39
9	20.8	3.4	20

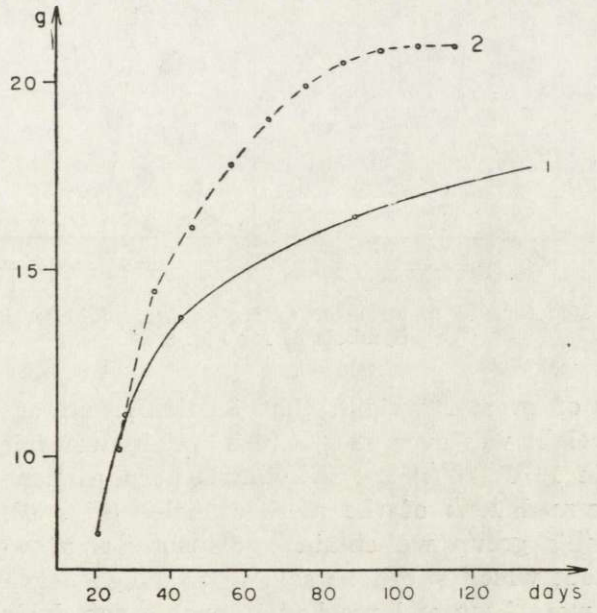

Fig. 4. Curve growth for weight of males in the isolated population (after Bujalska & Gliwicz, 1968) (continuous line), and in the unrestricted population (dotted line).

Comparison of growth curves for males in the unrestricted and island populations (from one to four months of life) showed that they are similar only during the initial period (30—50 days). The phase of rapid growth rate in the unrestricted population is longer (np to approx. the 3rd month of life) than the same period in the isolated population (2 months of life).

In accordance with data for the island population (Gliwicz *et al.*, 1968) the maximum age which marked individuals can attain in a given series is approx. 2 months (average 46 days). These are individuals which reached trappable age (21st day of life) during the 36-day interval between series, at the earliest after the end of the preceding series, which according to the growth of individuals in the island population corresponds to a weight of 15 g. In the unrestricted population males 2 months old attain a weight of 17.8 ± 1.8. About 60% of the newly marked males weigh approximately the above value.

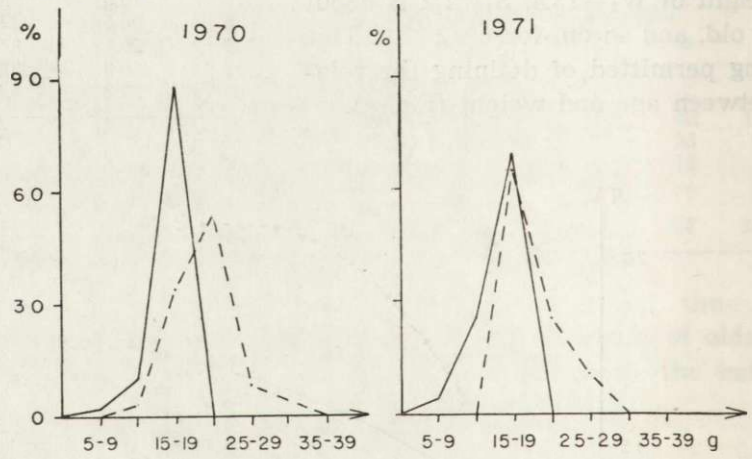

Fig. 5. Weight structure of males after excluding individuals weighing over 19 g. Symbols as for Fig. 3.

Individuals of greater weight, that is, the group of males marked when their weight was over 19 g, which weight was fairly numerously represented in 1970 (38%) are individuals born earlier. In 1971 these individuals formed 13% of the marked males (Fig. 3B).

Excluding this group we obtain a distribution of weights (Fig. 5) for males, about which it can be said with a high degree of probability that they were born and reached trappable age during the interval between two consecutive trapping series. This distribution is, however, still similar to the weight structure of males about 1.5 months older

in the island population. This is due to the more rapid growth rate of males in the open forest population, and therefore to the more rapid balancing of their weights than in the isolated population.

5. DISCUSSION

The results presented show that fairly significant differences occur between populations. The conditions in the open forest enable migration of individuals (Andrzejewski & Wierzbowska, 1960; Andrzejewski, 1963), whereas it is not possible in the island population. This fact may exert a significant influence on the mechanism regulating numbers. The different character found for variations in numbers in the unrestricted and the isolated populationu point to different distribution of intensivity of reproduction in these populations. The number of reproducing individuals increases with increase in numbers in the unrestricted population, as is show by the large numbers of individuals entering the population at the end of summer and in autumn. In the isolated population there are stabilized numbers of reproducing females, as the result of their territorial tendency and/or the limited area of the island. This group is formed primarily by old adult females and females born in spring of the given year. This leads to a considerable reserve of immature females in the population (Bujalska, 1970). In the open forest the majority of the females mature in the year of their birth, and the numbers of immature females are very low (Bujalska, unpubl. data).

The growth index is more correlated with maturity and sexual activity than with age (Schwarz, 1964; Zejda, 1971; Bujalska & Gliwicz, 1972). Analysis of age, body dimensions and weight of bank voles from the Białowieża National Park showed that they can attain the size of adult animals as early as the second month of life (Wasilewski, 1952).

It would seem that the absence of spatial limitation and possibility of migration do not make it necessary to set in motion the mechanism regulating numbers through inhibiting the maturation rate of young individuals in the population, which process probably takes place on the island (Bujalska, 1970). As a result of the more rapid rate at which voles mature in the unrestricted population, the animals grow more quickly, as shown by the growth curve presented and the »heavier« and more balanced weight structure of newly-marked animals.

In the isolated population the structure of newly-marked individuals was observed to be constant in successive study years. In the unres-

tricted population we found an almost constant percentage of individuals within the weight range of 15—19 g (56% in 1970, 60% in 1971) and a different percentage of the heaviest individuals (38% in 1970, 13% in 1971), and correspondingly of the lightest individuals (5% in 1970, 22% in 1971). Individuals weighing over 19 are older than those born in the study area during the interval between trappings, and they had thus immigrated into the study area. It was found, in the same area, that intensity of exchange of resident individuals due to the settlement and emigration is reserve proportionally to the number of resident individuals (Andrzejewski, 1963). Thus in the unrestricted population the weight structure of individuals at the time of marking may reflect the migration level for the given year, while the absence of this phenomenon on the island results in constancy of the structure of newly-marked individuals in successive years.

REFERENCES

1. Andrzejewski R. & Wierzbowska T., 1960: On the degree of residency and migrancy in populations of small rodents. Bull. Acad. Pol. Sci., Cl. II, *3*, 7: 293—300.
2. Andrzejewski R., 1963: Processes of incoming, settlement and disapperance of individuals and variations in the numbers of small rodents. Acta theriol., 7, 11: 169—213.
3. Bujalska G., Andrzejewski R. & Petrusewicz K., 1968: Productivity investigation of island population of *Clethrionomys glareolus* (Schreber, 1780). II. Reproduction. Acta theriol., *13*, 24: 415—425.
4. Bujalska G. & Gliwicz J., 1968: Productivy investigation of an island population of *Clethrionomys glareolus* (Schreber, 1780). III. Individual growth curve. Acta theriol., *13*, 25: 427—433.
5. Bujalska G., 1970: Reproduction stabilizing elements in an island population of *Clethrionomys glareolus* (Schreber, 1780). Acta theriol., *15*, 25: 381—421.
6. Bujalska G. & Gliwicz J., 1972: Growth and reproduction of female bank vole under field conditions. Acta theriol., *17*, 3: 33—40.
7. Gliwicz J., Andrzejewski R., Bujalska G. & Petrusewicz K., 1968: Productivity investigation of an island population of *Clethrionomys glareolus* (Schreber, 1780). I. Dynamics of cohorts. Acta theriol., *13*, 23: 401—413.
8. Petrusewicz K., Bujalska G., Andrzejewski R. & Gliwicz J., 1971: Productivity processes in an island population of *Clethrionomys glareolus*. Ann zool. Fennici *8*: 127—132.
9. Schwarz S. S., Pokrovski A. V., Istschenko V. G., Olenjev V. G., Ovtschinnikova N. A. & Pjastolova O. A., 1964: Biological peculiarities of seasonal generations of rodents, with special reference to the problem of senescence in mammals. Acta theriol., *8*: 11—43.
10. Traczyk H., 1965: The vegetation of the Wild Apple-Tree Island on the Lake Bełdańskie (North-Eastern Poland). Fragm. flor. geobot., *11*, 4: 541—545.

11. Traczyk H. & Traczyk T., 1965: Charakterystyka fitosocjologiczna terenów badawczych Instytutu Ekologii PAN w Dziekanowie Leśnym (Puszcza Kampinowska) — Phytosociological characteristics of the research areas of the Institute of Ecology, Polish Academy of Sciences at Dziekanów Leśny (Kampinos Forest near Warsaw). Fragm. flor. geobot., *11*, 4: 547—562.
12. Wasilewski W., 1952: Badania nad morfologią *Clethrionomys glareolus glareolus* Schreb. [Morphological investigations of *C. glareolus*]. Annls Univ. M. Curie-Skłodowska, C, 7, 3: 119—214.
13. Zejda J., 1971: Differential growth of three cohorts of bank vole, *Clethrionomys glareolus*, Schreb. 1780. Zool. Listy, *20*, 3: 229—245.

Accepted, September 4, 1972.

Institute of Ecology,
Polish Academy of Sciences,
Dziekanów n/Warszawa. Poland.

Maria MAZURKIEWICZ

ZAGĘSZCZENIE I STRUKTURA WAGOWA POPULACJI *CLETHRIONOMYS GLAREOUS* (SCHREBER, 1780) W WARUNKACH OTWARTEJ I OGRANICZONEJ PRZESTRZENI

Streszczenie

Porównano dynamikę liczebności, strukturę ciężarów osobników złowionych po raz pierwszy oraz tempo wzrostu osobników dwu populacji *C. glareolus*: populacji zamieszkującej wyspę o pow. 4 ha na jeziorze Bełdany oraz populacji otwartej, której badania prowadzono na terenie Kampinoskiego Parku Narodowego.

Analizowany materiał został uzyskany z badań populacji wyspowej w latach 1966—1968 oraz z badań populacji otwartej w latach 1970—1971. Metodykę zbierania danych oparto na zasadzie *CMR*. W każdym roku od wiosny do jesieni przeprowadzono 5 serii połowów w odstępie około 1 miesiąca.

Stwierdzono, że przebieg zmian zagęszczenia populacji otwartej jest podobny w obu badanych latach. Największą liczebność uzyskuje populacja w październiku (Fig. 2, Tabela 1). Populacja izolowana w latach szczytu uzyskuje maksymalne zagęszczenie w okresie letnim a w roku niskiej liczebności, zagęszczenie utrzymuje się na stałym poziomie od czerwca do października (Fig. 1, Tabela 1). Struktura ciężarów osobników pierwszy raz złowionych w populacji otwartej jest „cięższa" niż w populacji izolowanej i odpowiada rozkładowi ciężarów osobników starszych w tej populacji o ok. 1,5 miesiąca (Fig. 3, A, B). Krzywe wzrostu samców w badanych populacjach są podane tylko w początkowym odcinku. Faza szybkiego tempa wzrostu w populacji otwartej jest dłuższa (do ok. 3 miesiąca życia) w porównaniu z tym okresem w populacji izolowanej (2 miesiąca życia) (Fig. 4).

Dyskutowane są przyczyny różnic między obu populacjami. Wydaje się, że możliwość migracji osobników w warunkach lasu otwartego jest istotnym momentem wpływającym na różny mechanizm regulacji liczebności.