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

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# A Population of *Clethrionomys glareolus pirinus* on the Vitosha Mountain, Bulgaria. IV. Production

[With 5 Tables & 2 Figs.]

Animal production per 6 ha was 4.2—5.3 kg live weight, 48%—54% of which was produced by the spring cohort. From 13%—15% of total production was formed by newborn young ($P_b$) and 52%—55% by the body growth of sucklings (to 21 days). Production during the reproduction season accounted for about 90%, and during winter about 10% of total production ($P_T$). Average biomass per 6 ha was 1.2 kg — 1.7 kg. Turnover was 3.1 and 3.5.

## 1. INTRODUCTION

The analysis present here is an attempt to define production, elimination, and turnover in a free-living population of *Clethrionomys glareolus*, considering production by different cohorts (due to reproduction and to body growth) along with production in winter.

Data were obtained by cooperation of the Institute of Ecology Polish Academy of Sciences and the Institute of Zoology, Bulgarian Academy of Sciences, under the International Biological Programme. Populations were censused four times during June and September 1967 and 1968 on a 6 ha plot in the spruce forest of Vitosha Mountain by the Standard Minimum method (see Markov, *et al.*, 1972b). Individual growth curves (Christov & Markov, 1972), natality estimates, population fluctuation and cohort survival indices have been reported (Markov *et al.*, 1972a, b). These four cohorts are defined by Markov *et al.*, 1972a.

## 2. PRODUCTION CALCULATIONS

Production ($P$) was calculated by the Nees & Dugdale method (Petrusewicz & Madfadyen, 1970) from growth data of

Christov & Markov (1972) and cohort viability data of Markov *et al.* (1972b). By plotting number of individuals against their weight, a curve, the area under which indicates cohort production (Figs. 1 and 2) is obtained. Total production of all cohorts constitutes population production. Reproductive production ($P_r$), production due to body growth ($P_g$), and the various cohort productions are easily distinguished by this method.

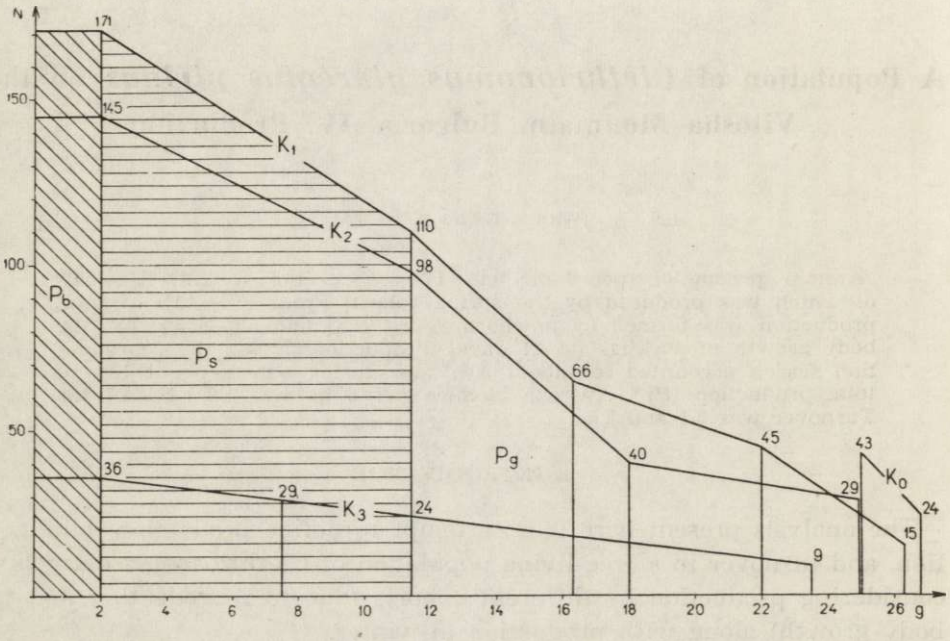


Fig. 1. Calculation of population production in 1967. Numbers of curves indicate the number of individuals which survived to the age expressed by weight on axis of abscissae. Production of each cohort is defined by the area under the given curve.

$P_p$ — weight of animals born, $P_s$ — production during period of feeding on mother's milk (up to 21 days): $P_g$ production due to body growth (production of independent components of the population). Values of numbers for 6 ha.

## 3. DISCUSSION OF POPULATION PRODUCTION

### 3.1 Cohort Production

Participation in annual production ($P$) by the various cohorts was analyzed, taking April 1, the beginning of the breeding season, as the beginning of the year. Thus a year in the *C. glareolus* population lasts from April 1 to March 31 the following year. Old adults form the starting point, spring and summer constitute a period of intensive reproduc-

tion, autumn and winter a period of reproductive quiesence, and the current year's generations survive to spring, starting the new breeding season.

Differential cohort production analysis (Table 1) shows that spring ($K_1$) and summer ($K_2$) cohorts clearly exhibit maximum production. Together they contribute 88—97% of total production. Old adults exhibit minimum production due to decreased body growth, only 1—2%. The autumn cohort (born in September) produces from 1% (1968) to 10% (1967).

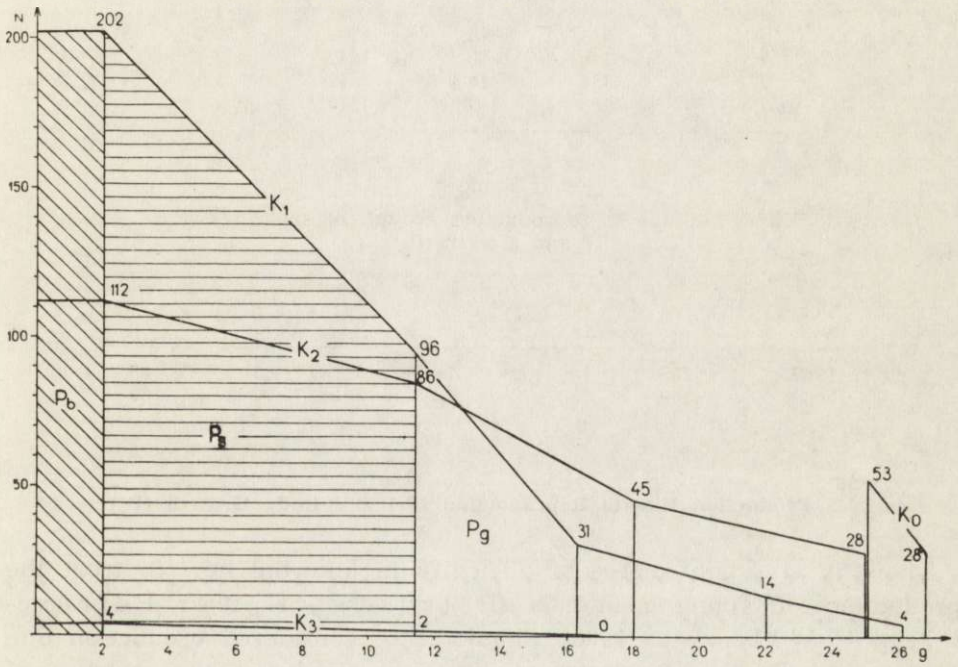


Fig. 2. Calculation of population production in 1968. Symbols as for Fig. 1.

It is difficult to exactly compare the portion of production contributed by cohorts from Vitosha Mountain with similarly analized results from a Polish island population of *C. glareolus* (Petrusewicz *et al.*, 1968, 1969, 1971) because cohorts in the two locations do not exactly correspond. $K_1$ and $K_4$ of Gliwicz *et al.* (1968) correspond approximately to $K_1$ and $K_3$ in the present study. In both populations spring and summer generations contribute greatly to production, but under the

conditions prevailing on Vitosha Mountain the earlier generation contributes more; $K_1$ produces 48%—54% of the total, whereas in Poland summer cohorts ($K_2$ and $K_3$) collectively produce more than the $K_1$. Average $K_1$ production for 3 years is 34% compared with 53% produced by $K_2$ and $K_3$ (Petrusewicz *et al.*, 1971).

Table 1

Participation of cohorts in production, yearly production per 6 ha in grammes of live weight.

| Cohort | 1967 | | 1968 | |
|---|---|---|---|---|
| | g | % | g | % |
| $K_0$ | 68 | 1.3 | 82 | 1.9 |
| $K_1$ | 2534 | 48.1 | 2283 | 53.7 |
| $K_2$ | 2129 | 40.2 | 1842 | 43.4 |
| $K_3$ | 554 | 10.4 | 42 | 1.0 |
| $P_{yr}$ | 5285 | 100 | 4249 | 100 |

Table 2

Production due to reproduction growth of sucklings ($P_s$) and growth ($P_g$).

| Year | $P_T$ | | $P_b$ | + $P_s$ | = $P_r$ | $P_g$ |
|---|---|---|---|---|---|---|
| | g | % | | % | | % |
| 1967 | 5285 | 100 | 13 | 52 | 65 | 35 |
| 1968 | 4249 | 100 | 15 | 55 | 70 | 30 |

### 3.2. Production Due to Reproduction ($P_r$) and Body Growth ($P_g$)

There is a certain degree of difficulty in knowing how to treat the production of young mammals (Petrusewicz, 1967; Petrusewicz & Walkowa, 1968). Should it be considered production due to breeding ($P_r$) since it occurs wholly or partially at the expense of maternal nourishment, or as body growth production ($P_g$)? By differentating between biomass of newborn individuals ($P_b$), biomass increase of sucklings ($P_s$), it was concluded that production occurs partly at the expense of the mother. Thus, $P_r = P_b + P_s$.

Table 2 shows that 52%—55% of production is due to suckling growth ($P_s$). Reproductive production is 65%—70% of all production. These values do not differ greatly from those obtained for the island population in Poland (Petrusewicz *et al.*, 1968), the numbers of which were accurately established. There, $P_b$ biomass was 13% compared with 13%—15% for the Vitosha population, and $P_r$ was 58%, compared with

65%—70% for Vitosha. It is difficult to judge whether the difference in production of sucklings (43% in Poland) is significantly less than for Vitosha since 4 population censuses were made yearly in Poland and the population was isolated, whereas on Vitosha Mountain the census was made only twice yearly.

Comparison of productivity during the breeding season (April—September) and winter (October—March) indicated that 88%—93% of net annual production occurs during the growing season (Table 3). This agrees with the Polish population data (Petrusewicz *et al.*, 1968), where only 10% of the total production occurs in winter.

Table 3

Production during winter and summer seasons.

| Period | Summer 1.IV — 22.IX | | Winter 22.IX — 1.IV | |
|---|---|---|---|---|
| | g | % | g | % |
| 1967 | 4612 | 88 | 613 | 12 |
| 1968 | 3940 | 93 | 309 | 7 |

Table 4

Production ($P$), elimination ($E$) and increase in standing crop ($B = B_T - B_o$) during reproduction and winter seasons.

| | | Reproduction period (IV — X) $P = E + (B_T - B_o)$ | Winter (X — III) $P = E + (B_T - B_o)$ |
|---|---|---|---|
| 1967 | g | 4612=3627+(2065−1080) | 637=1372+(1330−2065) |
| | % | 100 79 21 | 100 215 −115 |
| 1868 | g | 3940=4034+(1236−1330) | 309= 743+ (802−1236) |
| | % | 100 103 −3 | 100 240 −140 |

### 3.3 Production and Elimination in Summer and Winter

In a balanced population almost all net production (averaged over several years) is eliminated so that biomass accumulation, $\Delta B = B_T - B_o$ in the equation $P = E + \Delta B$ is very small. It is, however, interesting to trace separately the fate of the biomass produced during the reproduction and the winter seasons. During the reproduction season 3%—21% of production is due to biomass growth, but during the winter most or even the all accumulated biomass is eliminated from the population (Table 4).

During the winter, production in the form of body growth in only 7% to 12% of the whole years' production, and is less than mortality. Consequently $\Delta B = B_T - B_o$ is a negative value; the standing crop decreases from autumn to spring by 434—735 g of biomass, *i. e.*, by approximately 35% of the autumn standing crop (Table 4).

## 4. AVERAGE BIOMASS AND TURNOVER

The average standing crop for the year (number of individuals, live weight, or number of biomass-days, during a year) describes a population well. Biomass-days ($\bar{B}.T.$) is perhaps the best estimate since this expresses the mass which consumes, assimilates, digests, and respires. The calculated values in Table 5 vary for the two study years and are clearly lower than in the population of *C. glareolus* in Poland. It is interesting that with markedly different standing crops that turnover is similar in both years and does not differ greatly from the turnover in the population in Poland (3.1 and 3.5 compared with 3.7; Petrusewicz *et al.*, 1969).

Table 5

Average biomass ($\bar{B}$), value of biomass-days ($\bar{B} \cdot T$) (live wt per year, per 6 ha in $10^3$ g) and turnover $\Theta$ (per year).

| Year | $\bar{B},T$ | $\bar{B} = \frac{\bar{B}T}{365}$ | $P$ | $\Theta = P\bar{B}$ |
|---|---|---|---|---|
| 1967 | 624.1 | 1.71 | 5.29 | 3.1 |
| 1968 | 442.3 | 1.21 | 4.25 | 3.5 |

It is remarkable that while production of young to 21 days old is 65%—70% of total production, the participation of sucklings in average biomass or in number of biomass-days is negligible since in the latter $\bar{B} \cdot T$ for 1967 is (35.1 : 624.1) 100 = 5.6%, and for 1968 (28.6 : 442.3) 100 = 6.4%. Despite the enormous number of individuals they weigh little and, more importantly, their lifetime as sucklings is very short, lasting at most 21 days. They therefore do not greatly affect the mass and number of individuals living over the course of the year.

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## POPULACJA *CLETHRIONOMYS GLAREOLUS PIRINUS* W LESIE ŚWIERKOWYM MASYWU WITOSZA W BUŁGARII. IV. PRODUKCJA

Streszczenie

W wolno żyjącej populacji *Clethrionomys glareolus* na masywie Witosza koło Sofii produkcja obliczona metodą graficzną Neesa i Dugdale'a (Petrusewicz i Macfadyen, 1970) wyniosła w różnych latach 4,2 — 5,3 kg biomasy/rok/6 ha (Tabela 1). Wyraźnie najwyższa była produkcja generacji wiosennej i wyniosła 48—54% całej produkcji, natomiast 52—55% całej produkcji stanowiła produkcja wzrostu młodych żywiących się, przynajmniej częściowo, kosztem matki (Tabela 2). Zaledwie 10% przypada na produkcję zimą (Tabela 3). Średnia biomasa w ciągu dwóch lat badanych wynosiła 1,21 — 1,71 kg biomasy/6 ha. Turnover biomasy obliczono na 3.1 i 3.5.