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AUTUMN HOME RANGE SIZE OF *APODEMUS AGRARIUS* AND SMALL MAMMAL POPULATION DYNAMICS IN THE RODENT ASSEMBLAGE OF A *QUERCO ROBORI-CARPINETUM* FOREST HABITAT

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Abstract. The population dynamics of a rodent assamblage in a habitat of *Querco robori-Carpinetum* was investigated for three years by means of live trapping on a 1-hectare plot on the Dráva Lowlands. The studied rodent assemblage was made up of four species, with 1007 specimens providing data from a total of 2184 captures. Capture parameters (number of captures, number of recaptures, number of individuals) were the highest in the case of *Apodemus agrarius* (Pallas 1771), especially in 1995 when it dominated the captures in the sampling area in autumn, with significantly higher values in all parameters. The sufficient number of recaptures allowed the calculation of autumn home range size values for *A. agrarius*: for juvenile males in 1994, and for adult males and females in 1995 and 1996. The latter two years had data that were statistically analysable. Males had significantly larger home ranges than females in both years. The comparison of the two years did not reveal difference either in the case of males or females. It was found that calculated home range size in *A. agrarius* was influenced by the combined effect of the number of captures on the one hand and the number of different trap stations visited on the other. Home range characteristics as expressed by the chosen capture parameters were unquestionably influenced by the observed unique population dynamics of *A. agraius*.

Keywords: Apodemus agrarius, *rodent assemblage, population dynamics, home range, minimum convex polygon*

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Introduction

Among the four species (*A. agrarius*, *Clethrionomys glareolus* (Schreber 1780), *Apodemus sylvaticus* (Linnaeus 1758), *Apodemus flavicollis* (Melchior 1834) of the rodent assamblage in our study area, the most studied species from the home range aspect are *C. glareolus* and *A. sylvaticus*. Home range characteristics of *C. glareolus* were investigated by means of live trapping (Mazurkiewicz 1971, 1983). The change in home range size of male and female *C. glareolus* was also analysed as a function of food source fluctuations (Andrzejewski and Mazurkiewicz 1976). Detailed data are available on the relation system of space use, home range and social organization within the population (Ylönen et al. 1988, Mironov 1990, Bujalska 1994). Considerable amounts of information have been published recently about the movement patterns and home range size of *A. sylvaticus*, relying mainly on the radio telemetry method (Wilson et al. 1992, Tew 1992, Tew and Macdonald 1993, 1994, Rogers and Gorman 1995). Knowledge about space use and home range sizes in *A. flavicollis* is more limited (Radda 1969, Wolton and Flowerdew 1985, Kotzageorgis and Mason 1996). Out of the species of the investigated rodent assamblage, *A. agrarius* was captured in the largest numbers, and this species produced the highest number of recaptures too. This species is less likely to be found inside various forest vegetation types, instead it prefers open habitat types with dense cover, as well as margin and transitional areas (Zejda 1967, Babińska-Werka et al. 1979, Szacki and Liro 1991). Some information have been published about the role of *A. agrarius* in small mammal communities, its space need and movement patterns. Its long distance movements, irrespective of it being dispersal move or sallies around the territory have been investigated. (Liro and Szacki 1987, Szacki and Liro 1991). It had earlier been established regarding small mammal movement patterns that the effective range of movements exceeds the diameter of the home range. (Crawley 1969). However, in order to detect and analyse long distance moves, the trapping grid method is not sufficient, conclude Liro and Szacki (1987) from investigations of *A. agrarius*.

Data on home range size of *A. agrarius* is available from Wierzbowska and Chełkowska (1970), who applied for the species the center of activity method (Hayne 1949), and the home range model based on a two-variable normal distribution catching probability (Calhoun and Casby 1958). The conditions for this type of home range calculations include intensive trapping, large sample size and high population density (Wierzbowska and Chełkowska 1970). It has been shown that effective home range size depends on the vegetation and habitat type, as determined mainly by food availability (Chełkowsa et al. 1985). Similarly, the range of movements, sallies and exploration trips can be dependent on the current state of plant cover and composition that can change with time, and influence, through food offer, population densities. *A. agrarius* populations have been studied in *Tilio-Carpinetum* (Andrzejewski et al. 1978, Chełkowska et al. 1985), and *Carici elongatae-Alnetum* (Andrzejewski et al. 1978, Gliwicz 1981), *Pino-Quercetum* and *Calamagrostio villosae-Pinetum* (Chełkowska et al. 1985).

The present study intends to contribute to the information about the home range characteristics of *A. agrarius* in *Querco robori-Carpinetum* vegetation, with new Hungarian data.

Study area

Our investigations were performed on the Dráva Lowlands in southern Hungary. The sampling grid was laid out on the terrace of Fekete-víz, between the villages Vajszló (N 45° 51', E 18° 00') and Páprád (N 45° 54', E 18° 01') in county Baranya.

The trapped area is a 1 hectare forest section of a *Querco robori-Carpinetum* association, surrounded by low and flat agricultural lands often covered with pools of precipitation.

The most characteristic plant species in the undergrowth are *Dentaria bulbifera, Asperula odorata, Asarum europeum, Primula vulgaris*. Hornbeam (*Carpinus betulus*) is present in the form of young specimens in the second layer of the canopy.

In spring, sections of the sampling area with the densest (90-100%) plant cover are characterised by high undergrowth comprising many weed species and those indicating dampness and soil rich in nitrogene. Characteristic species are *Corydalis cava, Anemone nemoralis, Stellaria holostea, Galium aparine, Veronica hederifolia, Lamium purpureum, Alliaria petiolata, Urtica dioica*. In places of the grid where undergrowth cover is 0-30 %, there is an almost uninterrupted blanket of fallen leaves, and patches of bare ground are also present, with plant species *Ficaria verna, Hedera helix, Ajuga reptans, Crataegus monogyna, Primula vulgaris*.

In autumn, sections with plant cover of 70-90% or as much as 100 %, are characterised with a dense, medium high undergrowth of multiple layers. *Lamium maculatum, Stellaria holostea, Circaea lutetiana, Carex divulsa, Colchicum autumnale, Hedera helix* characterise the herb layer, while the upper layer comprises *Urtica dioica, Solidago gigantea, Dactylis glomerata*, and scattered specimens of *Rubus sp., Tamus communis, Stenactis annua*. Patches with pure blanket of leaves are common in sections with 0-20% cover, with scattered *Circaea lutetiana, Hedera helix, Pulmonaria officinalis, Asperula odorata* specimens. The upper layer has a cover of 60%, made up mainly by small, almost creeping specimens of *Ligustrum vulgare*.

Material and methods

With its 81 box-type live traps laid down in 9 rows at a distance of 12.5 m from each other, the grid covered an area of 1 hectare. Traps operated for three consecutive nigths from March to October 1994 and March to May 1995, then for four nights from June to October 1995 and from February through November 1996. Thus, sampling during the three years yielded a total of 7533 trap nights. Traps were checked twice daily (8^{00} CET and 18^{00} CET). For individual identification of the captured animals, the removal of the first knuckle of certain toes was applied, and the following data were recorded: species, sex (gravidity and lactation in females), body weight.

Capture data were collected in a Manly-Parr diary of captures. Throughout the three years the changes in population sizes in time were monitored using the index "minimum number alive" (= MNA)

(Boonstra and Krebs 1978, Boonstra and Rodd 1984) based on capture data. Capture parameters of the different species (i.e. total number of captures, number of recaptures, number of captured individuals, MNA) were compared using the two-sample *t*-test (Zar 1996).

The home range analysis of *A. agrarius* was possible using the autumn trapping data (1994 and 1995: from late August through late October, 1996: from late August till the end of November). Based on data from the three autumn periods, three categories of *A. agrarius* were differentiated: young males in 1994, adult males and females in 1995 and 1996. Individuals captured at least four times and having used a minimum of three traps were included in our calculations. For estimating home rage size, the "minimum convex polygon" (MCP) estimator of the computer programme "McPAAL" (Stüwe 1988) was used. For making comparisons between sizes of home range area of sexes and between those of the 1995 and 1996 autumn trapping periods within the same sex category, the Mann-Whitney *U*-test was applied (Zar 1996). To test a possible correlation of home range size with weight of *A. agrarius* individuals, regression analysis was performed.

Results

Four rodent species were captured during the study period, with the bulk of the captures being made up by specimens of *A. agrarius*, as is indicated by capture, recapture and abundance data in the three years (Fig. 1). A total of 2184 captures denote the following distribution of the four species: *A. agrarius* (AAGR) 405, *A. flavicollis* (AFLA) 284, *A. sylvaticus* (ASYL) 92, *C. glareolus* (CGLA) 226 specimens.

The yearly trends in population changes of the four species are indicated by the MNA values of the three years (Fig. 2).

In 1994 *A. agrarius* was first caught as late as in May, then, together with *A. flavicollis*, it reached an abundance peak by September. According to monthly values of captures, individuals and MNA, *C. glareolus* was found to be significantly more abundant than *A. sylvaticus* (total number of captures: $t = 2.43$, $df = 14$, $p < 0.05$; number of captured individuals: $t = 2.19$, $df = 14$, $p < 0.05$; MNA: $t = 2.81$, $df = 14$, $p < 0.02$). As regards recaptures, there was no significant difference among the four species when the whole year period was analysed. The *t*-test of the calculated values was run for the the autumn period in itself, too, which revealed that significantly more indfividuals *of A. flavicollis* were identified than *A. sylvaticus*(number

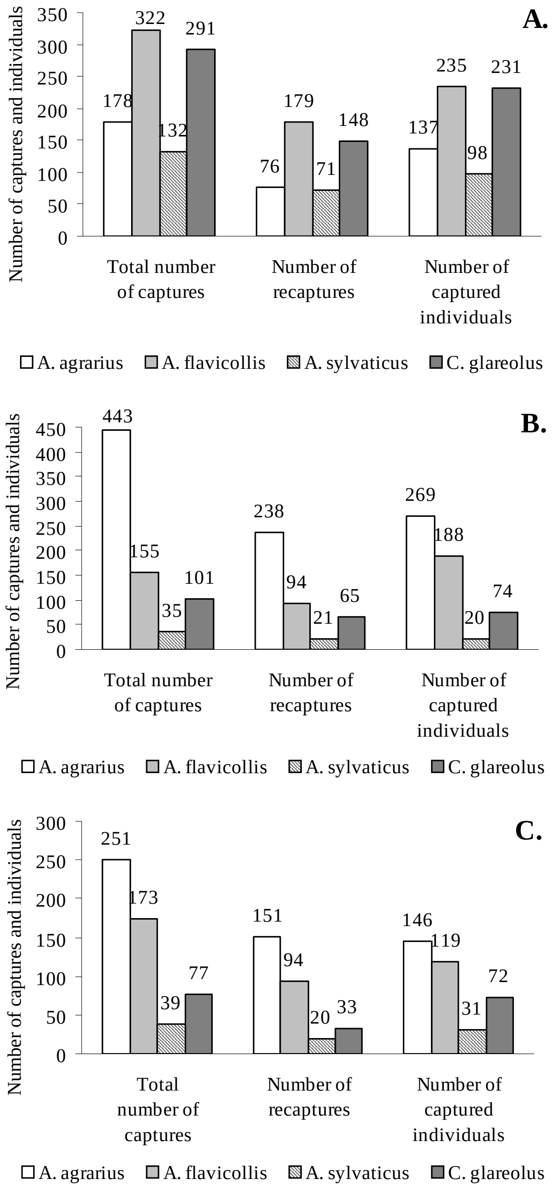

Fig. 1. Captures, recaptures and number of individuals for the four rodent species. A: 1994, B: 1995, C: 1996.

of captured individuals: $t = 4.66$, $df = 4$, $p < 0.01$; MNA: $t = 8.24$, $df = 4$, $p < 0.01$), and, from the aspect of capture numbers and MNA, *A. flavicollis* turned out to be more abundant than *C. glareolus* (total number of captures: $t = 3.72$, $df = 4$, $p < 0.05$; MNA: $t = 3.05$, $df = 4$, $p < 0.05$). The reason for the latter difference is that in 1994 the population maximum of *C. glareolus* occurred in mid-Summer, unlike in that of the *Apodemus* species.

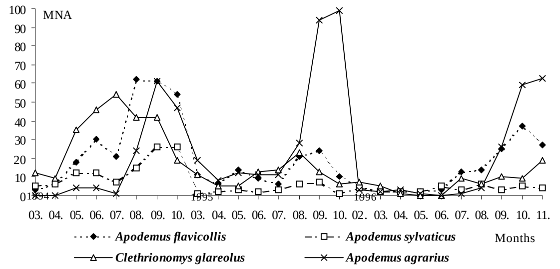

Fig. 2. Minimum number alive values of the species in 1994-1996.

Table 1. Comparison of capture data of *A. sylvaticus* with those of the three other species in 1995. df =14, * p < 0.01, ** p < 0.02, *** p < 0.05.

Species		AAGR	AFLA	CGLA
	Capture parameters		t - values	
ASYL	Total number of captures	2.42***	3.58*	2.82**
	Number of recaptures	2.35***	4.05*	2.89**
	Number of captured individuals	2.4***	3.56*	2.89**
	MNA	2.36***	3.81*	3.55*

The 1995 study period shows an entirely different picture: more *A. agrarius* were captured each month than in the previous year, and its population build-up forming by September-October exceeded by far that in 1994 (Fig. 2). Capture values for the rest of the species suffered a marked decrease. The least abundant was *A. sylvaticus*: each calculated parameter for this species was significantly lower than those of any of the three other rodent species. (Table 1). The striking autumn population growth in *A. agraius* is well demonstrated by its significantly higher number of captures in autumn than any of the other species (AAGR vs. AFLA: $t = 2.87$, $df = 4$, $p < 0.05$; AAGR vs. ASYL: $t = 3.67$, $df = 4$, $p < 0.05$; AAG vs. CGLA: $t = 3.25$, $df = 4$, $p < 0.05$). In the comparison of autumn recaptures, the values for *A. agrarius* were found to be higher only than those of *A. sylvaticus* ($t = 2.85$, $df = 4$, $p < 0.05$), which is attributable to the fact that a considerable proportion of the high number of *A. agrarius* captures in this period was made up by newcomer individuals to the area, and recaptures contributed to the high abundance value only with a relatively low number.

By spring 1996, rodent populations were found to have declined as a result of the long and severe winter of 1995/1996 and the weather in March wich was cold for the season. In the period until August much less animals could be captured than in the same period of the two preceding years, which is well indicated by capture parameters (Figs 1 and 2), and the studied populations could not reach an abundance peak like the one in 1994, not even by September. *A. agrarius*, again, turned out to be the most abundantly trappable species in autumn 1996, but only with a lower maximum than in 1995.

Our data describe a rapid growth of the *A. agraius* population, culminating in autumn, and a subsequent considerable drop in numbers by spring of the following year. This trend was most marked in 1995 with *A. agrarius* becoming by autumn the most frequent species, trapped in highest numbers on the study plot, as is confirmed by data in Tables 2 and 3. When spring and autumn capture data are compared, the *t*-test reveals higher autumn capture values for each year (1994: $t = 4.92$. $df = 6$, $p < 0.01$; 1995: $t = 4.45$, $df = 6$, $p < 0.01$; 1996: $t = 2.83$, $df = 8$, $p < 0.05$). The relatively high number of new individuals trapped in autumn suggests a dispersal of the species from open areas into the forest.

As it is shown by figures appearing together with capture parameters of *A. agrarius* for complete years (Table 2), most of the individuals were captured only once, which characterizes the separate autumn data series (Table 3), too. The rapid population increase in autumn is transparent if figures in these two tables are compared; i.e. figures appearing in the table of autumn data are high percentages of the whole-year figures, showing that most of the captures occurred in autumn. Out of *A. agrarius* individuals captured only once, 96 % , 75 %, and 93 % were caught in autumn in 1994, 1995 and 1996, respectively. Thus, data sufficient for home range calculations are available only from the autumn trapping periods. Table 3 categorises the yearly number of *A. agrarius* individuals captured at two or more different trap stations in the autumn periods. Many individuals were encountered in 2 or 3 different traps, and neither of the known specimens visited more than 5 different stations. In 1994 data of a few young males, while in 1995 and 1996 more specimens both adult males and females were included in the home range size calculations.

MCP values and their staistical evaluations are separated based on these categories (Table 4). Because of the small sample size, the home range data of young males captured in 1994 were not included in the statistical comparison of years. First, home range size of adult males and females were compared for autumn 1995, then for autumn 1996. According to the results of the Mann-Whitney *U*-test,

Table 2. Capture data of *Apodemus agrarius* in the entire trapping period 1994-1996.

Years	Trap nights	Total number of captures	Number of recaptures	Number of captured individuals	Mean number of capt./mouse	Number of mice captured 1-10 times									
						1	2	3	4	5	6	7	8	9	10
1994	1944	178	76	1.37	1.29	53	20	16	9	-	1	-	-	-	-
1995	2349	443	238	269	1.64	101	55	200	18	9	2	2	2	-	1
1996	3240	251	151	146	1.71	32	30	17	15	7	3	1	-	1	1

Table 3. Capture data of *Apodemus agrarius* in the autumn periods.

Years	Trap nights	Total number of captures	Number of recaptures	Number of captured individuals	Mean number of captures/mouse	Mean number of captures/mouse for recaptured mice
1994	729	166	71	128	1.29	2.15
1995	972	355	184	212	1.67	2.13
1996	1296	234	135	136	1.72	2.2

Years	Number of mice captured 1 - 10 times										Number of mice captured at 2 and more different trap stations			
	1	2	3	4	5	6	7	8	9	10	2	3	4	5
1994	51	20	15	8	-	1	-	-	-	-	24	10	3	-
1995	76	48	18	13	8	1	3	1	-	-	51	15	10	2
1996	30	28	18	13	7	3	1	-	-	1	32	24	5	3

Table 4. Home range size of *A. agrarius* in the autumn periods in 1994-1996.

Years	Group (sex and age)	Valid N	Mean of MCP (m^2)	Confid. - 95%	Confid. + 95%	Minimum MCP size	Maximum MCP size	Std. Dev.
1994	Male juv.	4	144	50.45	237.54	72	216	58.78
1995	Male ad.	9	376	215.17	536.82	144	792	209.22
	Female ad.	6	140.97	135.96	143.98	78.125	234	72.53
1996	Male ad.	10	210.95	108.64	313.25	78.128	469	143.01
	Female ad.	7	245.31	52.19	438.42	78.18	703	208.8

adult males had significantly larger home ranges in both years than adult females (1995: $U = 51$, $p < 0.005$; 1996: $U = 51$, $p < 0.05$). However, when the two years are compared, home ranges do not differ significantly either in the case of males or females. (ad. males: $U = 65$, NS; ad. females: $U = 14$, NS).

The regression of home range vs. body weight of the sexes was done separately for the three trapping periods, since the size of the *A. agrarius* population as well as the composition of the rodent community were entirely different in the autumn of the three periods. However, significant correlation was not found in either of the cases. The values of the correlation coefficient were the highest in the case of the 1996 data, obtained for a positive linear correlation for females ($r = 0.446$, $df = 4$, NS), and a negative exponential relationship for males ($r = 0.685$, $df = 4$, NS).

Each *A. agrarius* individual that had ben attributed an MCP value was considered when plotting home range sizes against individual capture numbers and number of different trap stations visited (Fig. 3). In the formation of MCP size values, the use of several different trap stations by the mice has an

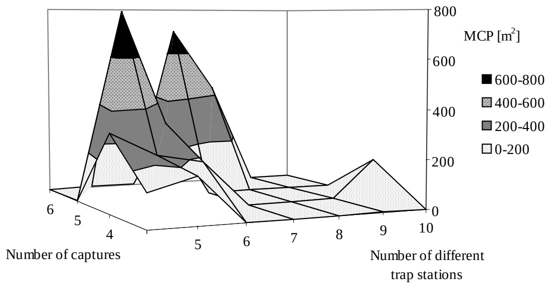

Fig. 3. Calculated MCP size values as a function of number of captures and trap variability. For different individuals with different MCP size values, but with the same number of captures and the same number of visited trap stations, the average of their home range sizes was put on the chart.

influential role. However, it was not possible to show a positive correlation between the number of captures and home range size. Out of the pool of *A. agrarius* individuals included in our calculations the highest home range size peak (Fig. 3), was obtained for individuals that were captured 5 times. The other peak occurred in the case of specimens with 6 captures, where the number of trap stations visited was also higher, although it did not exceed the value of the former maximum.

Discussion

In the four-species rodent assablage of the investigated *Querco robori-Carpinetum* habitat the autumn dominance of *A. agrarius* was shown. This species is known from literature (Andrzejewski and Wrocłavek 1961) to exhibit abrupt autumn population growths. This yearly cycle was most predominant in 1995 when *A. agrarius* completely had spread in the forest habitat by autumn, and had become trappable throughout the 1-hectare grid, despite its ecoton preference having been described by earlier investigations (Zejda 1967, Babińska-Werka et al. 1979, Szacki and Liro 1991). From the data in autumn 1995, the presence of a gradation was concluded which suffered a drastic collapse by spring 1996. A similar event was covered in a case study by Andrzejewski and Wrocłavek (1961).

From our case, the question arises here whether or not the species composition of the studied rodent assamblage and changes in it depend on the size of the actual populations. What kind of relation exists between changes in the structure of the species assemblage and the changes of the structure of co-existing populations? The changes in *A. agrarius* population size in cultivated lands were studied in the presence of *M. arvalis* (Pall.) and *A. flavicollis* (Adamczewska-Andrzejewska et al. 1981). It was found that the increase in the number of mature *A. agrarius* females appeared only at a certain level of density, and showed a decrease beyond a threshold level, while in the case of *M. arvalis* the ratio of mature females grew steadily following the pace at which the size of the population increased, and reproduction followed a linear growth. As opposed to *A. agrarius*, there is no negative feedback from density on reproduction in *M. arvalis*. When the *A. agrarius* population co-existing with *C. glareolus* was removed, Bujalska and Janion (1981) recorded an increase in the number of reproductive *C. glareolus* females, meaning that a change in the structure of the community was followed by a shift in the structure of the *C. glareolus* population.

Our results showed that population sizes in the rodent assamblage were different in the three study years. The autumn increse in the densities of the populations also differed from species to species. In 1995 *A. agrarius* was predominant in comparison with the rest of the species. The home range size values of either male or female *A. agrarius* were not different when 1995 and 1996 were compared. From these we can conclude that in forming home range sizes characteristic for males and females respectively, the role of interactions between different populations was rather insignificant.

The home range size of rodents is determined by a composite of almost innumerable factors the separate identification of which is extremely problematic. Examples showed that home range size decreases as a function of increasing plant cover (e.g. Getz 1961), and, similarly, smaller home ranges are revealed when density increases (Van Vleck 1969) or the amount of available food is greater (Andrzejewski and Mazurkiewicz 1976). Besides, behavioural characteristics of various functional groups of a population may have an influential role in forming certain home range variations (Korn 1986). From his results Korn (1986) concluded that average values in the case of home range can be misleading, therefore suggests that as many functional groups of individuals be differentiated as possible instead of using mean values, so as to be able to correctly interpret the observed phenomena. Similarly, it can be deceiving if averages from the data of a longer time period are created unconditionally in home range calculations, since temporal intervals defining actual home ranges can be in some cases as short as only a few hours (Mironov 1990). Bearing in mind the suggestions mentioned above, age and sex categories were differentiated in the present study, and time intervals were separated. For autumn 1995 and 1996, it was possible to use data of only adult males and females. *A. agrarius* males had significantly larger home ranges than females. In accordance with these findings, when examining territoriality of *C. glareolus* males and females (Bujalska 1994), and in the study of the same species and *A. sylvaticus* (Korn 1986) it was found that females had smaller home ranges than males. Unfortunately, since we had calculations based on only one period in both years, it was not possible to obtain statistically comparable home range overlap data.

One autumn period in each year of the investigations can not provide sufficient data to answer how much the variations in the home range size of *A. agarius* depend on factors like vegetation cover, population density and food availability. To reveal these, much more capture data are needed. However, even in the case of a very intensive capture programme operating with more traps, the results can be seriously influenced by the unpredictable population dynamics of *A. agrarius*.

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