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The Population Structure and Dynamics of Small Mammals in Set Aside Areas in Western Switzerland

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Abstract: In this paper in order to assess the effect of set aside to small mammal populations, one year field study using mark and recapture method was performed in set aside fields in Salavaux, Chevroux and Montbrelloz in western Switzerland. There are 3 species were regularly caught in the set asides: the common vole (*Microtus arvalis*), the white toothed shrew (*Crocidura russula*), and the wood mouse (*Apodemus sylvaticus*). The common vole was the most numerous species in the three set aside fields. Population size of common voles was different between the set aside, but fluctuations in animal numbers were similar, showing a rapid increase as cover and food abundance increased in the set asides during late spring, leading to peak in midsummer. The age structure differed between males and females, most individuals captured during this study are adults and subadults. There were more subadult males than female and more adult females than males ($x^2 = 44.09$, $df = 10$, $P < 0.001$, N = 203). There was a significant difference in body mass between the sexes among common voles, males were significantly heavier than females (t-test unequal variances: $t = 5.011$, $df = 162$, $P < 0.05$, N = 213). The sex ratio was very different for the different months, females being more frequently captured than males and there was no similarity between the set asides. The home range size of common voles lied between 350 and 400 m^2; the individuals move only short distances and there were no significant differences between males and females.

Key words: Small mammals; Common vole (*Microtus arvalis*); Population structure; Set aside

瑞士西部农田周围生态保留带中小型兽类种群结构特征及数量动态的初步研究

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摘要: 为了评价生态保留带对小型兽类种群的影响, 2003 年 7 月至 2004 年 6 月在瑞士西部 Salavaux, Chevroux 和 Montbrelloz 3 个地区采用标志重捕方法对小型兽类种群进行了研究。在 3 个生态保留带中, 共发现 6 种 1 206 只小型兽类, 其中普通田鼠、小林姬鼠、中麝鼩捕获数量多。普通田鼠为优势种。普通田鼠的种群数量在生态保留带间有差异, 但具有相同的季节性波动趋势, 一般种群数量随着植被覆盖度和食物丰富度的增加, 春季末开始出现增加, 仲夏达到最高水平。种群中雌雄个体年龄结构之间有明显的差异, 成体和亚成体的数量比幼体多, 雄性亚成体的数量比雌性多, 雌性成体数量比雄性多 ($x^2 = 44.09$, $df = 10$, $P < 0.001$, N = 203)。普通田鼠种群中雌雄个体体重之间有明显的差异, 雄性的体重比雌性大 (t - 检验: $t = 5.011$, $df = 162$, $P < 0.05$, N = 213)。种群性比之间有明显的月间变化, 雌性的捕获次数比雄性大。普通田鼠只在短距离范围内活动, 在生态保留带中的巢区为 350～400 m^2, 雌雄个体的巢区大小之间没有显著性差异。

关键词: 小型兽类; 普通田鼠; 种群结构; 生态保留带
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The study of population dynamics and population structure characteristics are one of important parts of small mammal population ecology. The significance of habitat characteristics affecting population dynamics of small mammals has been studied intensively (Flowerdew, 1985; Rogers and Gorman, 1995; Delattre *et al*., 1996; Zejda and Nesvadbova, 2000). Generally, the better the habitat quality, the greater the levels of immigration, abundance, survival, recruitment, length of breeding season, and body mass of small mammals (Rogers and Gorman, 1995). Food availability is presumed to be the primary factor affecting small mammal population

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dynamics (Wilson *et al*., 1993; Montgomery and Dowie, 1993; Francois, 1997).

For the past several decades increased farming intensity has resulted in a decrease in faunal and floral diversity in agricultural areas (Duelli, 1997; Barone and Frank, 2003). There also has been a loss of natural habitats with the intensification of agricultural practices (Nentwig, 2003; Frank, 2003; Duelli and Obrist, 2003). The importance of agricultural areas for the conservation of biodiversity is increasingly recognized in most European countries.

Set aside is a European Union agricultural practice that was introduced in 1988 to reduce surplus arable crops. The primary aim of this scheme is to reduce food production rather than to promote environmental management. Thus land may return to agricultural production as part of the set aside rotation, or at the end of a set aside period (Rogers and Gorman, 1995; Milton *et al*., 1997). Set asides have been progressively introduced into the Swiss agricultural landscape over the last decade. Set asides are linear habitats containing 20 - 25 herbivorous species, sown inside or along the edge of fields. Set asides are valuable compensation areas, as they are not only an aesthetic enrichment of the landscape, but connect semi-natural habitats (Lys and Nentwig, 1992; Frank and Nentwig, 1995; Frank, 1998). Set asides also offer food resources, over-wintering sites and refuges for many arthropod groups. Thus, set aside land can be beneficial to several fauna groups, including mammals (Baumann, 1996; Briner, 2002). Farmers, however, are concerned about negative effects from dispersal of pest species into adjacent crop fields.

The special characteristics of set aside areas could affect population dynamics, population structure and species distribution of small mammals. The aims of this work were to study (1) species composition of small mammals in set aside areas; (2) population density and dynamics of each species; (3) movements of individuals within the area and outside of it.

1 Material and Methods

1.1 Study area

This research was carried out from July, 2003 to June, 2004 on set aside areas in Salavaux, Chevroux and Montbrelloz, 60 km west of Bern. The altitude of the study sites varied between 439 m and 499 m and the size of study area were 2.55 ha, 4.5 ha and 6.7 ha. The set asides were selected to lie in the same climate zone providing similar site condition in terms of altitude, mean annual rainfall and temperature. Set aside has to be maintained for at least two, maximum six years. In the three set asides of study all 25 sown plant species were observed, the set asides were dominated by the sown *Fagopyrum esculentum*, *Leucanthemum vulgare*, *Trifolium repen* in Salavaux, *Dipsacus fullonum*, *Tanacetum vulgare*, and *Reseda lutea* in Chevroux, *Seuls Achillea millefolium*, *Dipsacus fullonum* in Montbrelloz.

1.2 Method

1.2.1 Trapping

Small mammals were caught using 7.7 cm ×7.7 cm ×25.5 cm Sherman and 25 cm ×6.5 cm ×8.5 cm Longworth lives traps. In each location, 2 grids of 64 traps (32 Longworth and 32 Sherman) were placed in the middle of the set aside field. The first grid was a square of 8 ×8 squares (area of 1 600 m^2) and the second one a rectangle of 4 ×16 squares (area of 1 600 m^2). The distance between traps was 5 m and the trap types alternated (Long worth-Sherman). Traps were placed in the morning around 8:00 am and collected 16:30 pm and checked 4 - 5 times per day at 2-hr intervals. Each trap was baited with a small amount of carrot, cheese and mixed seeds; hay was provided as bedding material. A given place was visited ever 3 weeks. From December, 2003 to February, 2004 trapping was conducted only one day (in order to avoid excessive trap mortality during cold weather); from July to November, 2003 and from March to June, 2004 the traps were left open overnight and were also checked regularly the second day. Upon capture, in order to manipulate the animals, more easily we anaesthetized them with Halothane liquid. Each animal was examined to identify species, gender, and age (i.e., adult, subadult, juvenile). Species, body mass, sex, breeding condition, ear tag number and trap position were recorded before releasing at the point of capture. Age classes were defined according to body mass (juvenile ≤10 g, 10 g < subadults ≤20 g, adults > 20 g) (Baumann, 1996; Briner, 2002). Home ranges were calculated according to the Minimum Convex Polygon method (MCP) (Mohr, 1947; Worton, 1987).

1.2.2 Data analysis

Population abundance was estimated for each grid using the Minimum Numbers Alive (MNA) (Krebs, 1966, 1999). It was not possible to use the more sophisticated Jolly-Seber model, because recaptures between months were so low. Population density, expressed as number of animals per hectare, was calculated from the MNA estimates on each grid. To compare vole body weight and body length between the different set aside, *t*-test (unequal variance) was performed. To compare vole body mass during the year, Kruskal-Wallis test was performed using Simstat program. A Mann-Whitney *U*-test was used to compare home range length in both sexes. Because of the linear shape of the set asides, we chose home range length rather than its area. For home range length, only voles trapped in at least two different traps during two or more capture periods were considered.

2 Results

2.1 Species composition of small mammals in set aside areas

In total we recorded 1 206 individuals representing 6 species in the area, three species were regularly caught in the set asides: the common vole (*Microtus arvalis*), the white-toothed shrew (*Crocidura russula*), and the wood mouse (*Apodemus sylvaticus*). One additional species, the fossorial form of the water vole (*Arvicola terretris terrestris*), was also observed inside the set asides, but only accidentally captured due to its subterraneous activity. The common Eurasian mole (*Talpa europaea*), was observed on a rough grazing inside the wood and occurred on the grassy field margins at the edge of the forest, but was never observed inside the set asides. The bank vole (*Clethrionomy glareolus*) was trapped only at the edge of the forest. According to the total number of individuals, 1 051 (87.14 %) were common voles, 93 (7.71 %) were white-toothed shrews, 56 (4.64 %) were wood mice, 3 (0.24 %) were *Arvicola terretris terrestris*, 1 (0.082 %) was *Talpa europaea*, and 2 (0.165 %) were *Clethrionomy glareolus*. The common vole was the most numerous species in the three set aside fields. The numbers of different species in three different set asides were shown in table 1.

Table 1 Small mammal species composition, captured number and captured rate in three different set asides area

	Salavaux		Chevroux		Montbrelloz		Total
	♂	♀	♂	♀	♂	♀	♀+♂
Number of trap	6144		6144		6144		18432
M. arvalis	435 (7.08)	396 (6.44)	97 (1.58)	85 (1.38)	25 (0.41)	13 (0.21)	1051 (5.7)
A. sylvaticus	15 (0.24)	9 (0.15)	6 (0.09)	13 (0.21)	7 (0.11)	6 (0.09)	56 (0.30)
C. russula			61 (0.99)	32 (0.52)			93 (0.50)
Arvicola terretris terrestris			2 (0.03)		1 (0.016)		3 (0.016)
Talpa europaea	1 (0.016)						1 (0.005)
Clethrionomy glareolus			2 (0.03)				2 (0.01)
Total number of animals	451 (7.34)	405 (6.59)	168 (2.73)	130 (2.12)	33 (0.53)	19 (0.31)	1206 (6.54)

Common white-toothed shrews were caught only in the set asides throughout the year and displayed similar seasonal fluctuations in numbers, as did the common vole. Although densities of the white-toothed shrew were positively correlated with densities of common voles ($r = 0.88$; $P < 0.001$; N = 12) (Fig. 1)

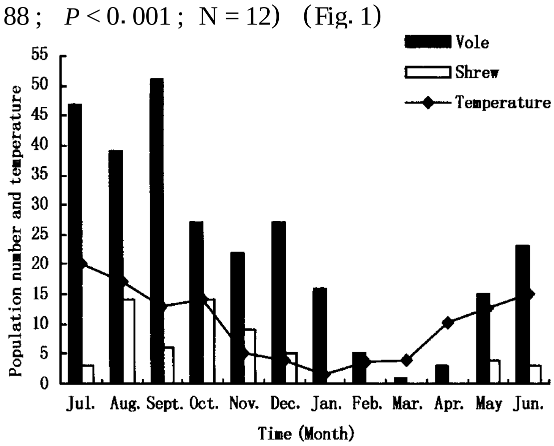

Fig. 1 Comparison of numbers as total of set asides of voles and shrew

2.2 Population structure and parameters of common vole in set asides

We found the common vole to be the most abundant species in the three set aside fields and, although there was no significant difference in body length between sexes among common voles (t-test: $t = 1.443$, $df = 188$, $P > 0.9$, N = 190), females were significantly heavier than males (t-test: $t = 2.473$, $df = 188$, $P < 0.05$, N = 190). If, however, only adult and non-gravid individuals were compared, there was a tendency for males to be heavier than females (Mann-Whitmey-U test, $U = 464$, $P = 0.1065$, N = 70) and significantly longer than females (Mann-Whitney-U test, $U = 374$, $P < 0.01$, N = 70). Body mass changed during the year with a tendency for animals to be heavier in summer than in winter, but there was no significance difference in body mass over the year (Kruskal-Wallis-test; $H = 18.025$, $P = 0.1071$, N = 327). Length and body mass were correlated ($r = 0.855$, $P < 0.001$, N = 192), but variability was so great within age groups, that it was not possible to estimate age of an individual age from the two parameters or to construct a time specific life table.

The maximum time-span between the first and last capture was 189 days for females and only 94 days males. Females were also captured more often than male ($U = 6045$, $P < 0.001$, $N = 190$; Fig. 2).

The sex ratio did not differ significantly from 1∶1 in the different strips, although there were noticeable fluctuations (x^2-contingency test, set aside A: $x^2 = 3.44$, $df = 11$, $0.99 > P > 0.975$, N = 78; set aside B: $x^2 = 13.79$, $df = 11$, $P > 0.25$, N = 76; set aside C: $x^2 = 12.825$, $df = 11$, $P > 0.1$, N = 122) (Fig. 3). The consistency of the sex ratio during the year was tested and revealed no departure from a 1∶1 ratio for all month controlled (x^2 = 14.09, df = 11, P > 0.1, N = 236).

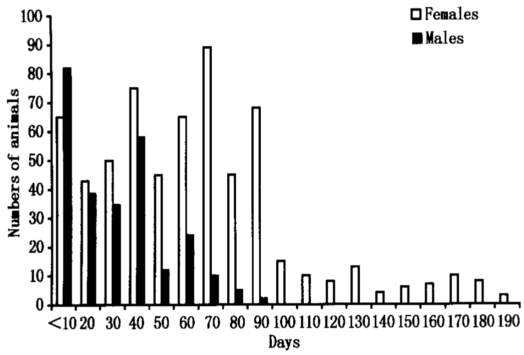

Fig. 2　Minimum presence of an individual inside the different set asides

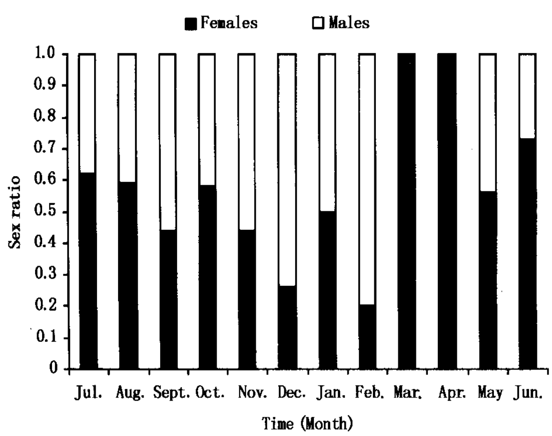

Fig. 3　The sex ratio in set aside 3 for each month

The age structure differed between males and females. There were more subadult males than females and more adult females than males (x^2 = 44.09, df = 10, P < 0.001, N = 236) (Fig. 4).

The age structure of population varied during the year, with numbers of subadults and juveniles increasing during spring, reaching a maximum in midsummer (Fig. 5).

The number of juveniles correlated with the number of active females (r = 0.894, P < 0.0001, N = 12), the number of subadults correlated with the number of previously active females (r = 0.893, P = 0.002, N = 12) and the number of sexually active females correlated strongly with the number of sexually active males (r = 0.99, P < 0.0001, N = 12) (Fig. 6).

Although population size varied over the year, common voles were equally abundant in the three set asides (x^2 = 54.25, df = 33, P < 0.01). The common vole was by far the dominant species, *Crocidura russula* was also fairly abundant, but was restricted to field margins. Mounds of *Arvicola terrestris* and *Talpa europaea* were present, but none was caught. The annual population dynamics for *Microtus arvalisare* shown on the Fig. 7.

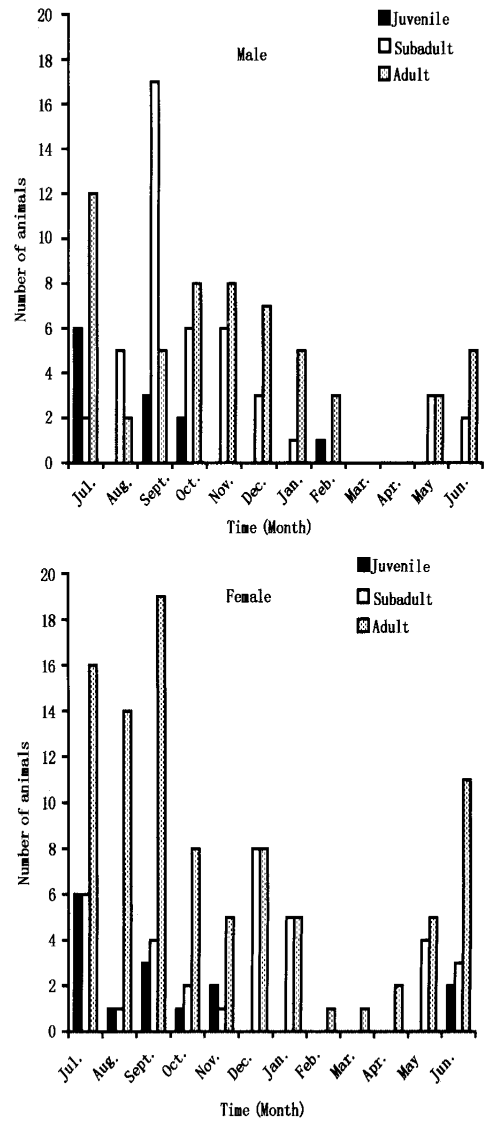

Fig. 4　Change in the age structure of the two genders during the year. The numbers are totals (MNA)

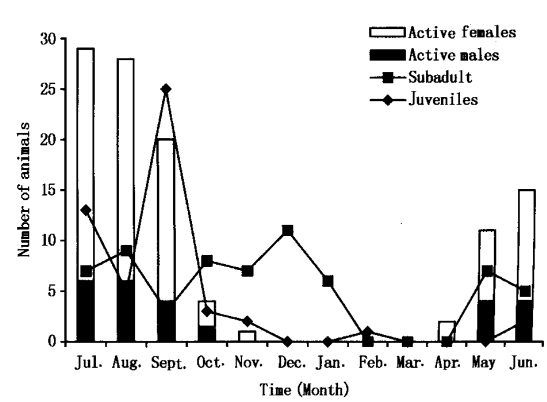

Fig. 5　Sexually activity and number of captured offspring of common voles in set aside 1 - 3 showing a correlation between increase in sexual activity and number of offspring capture

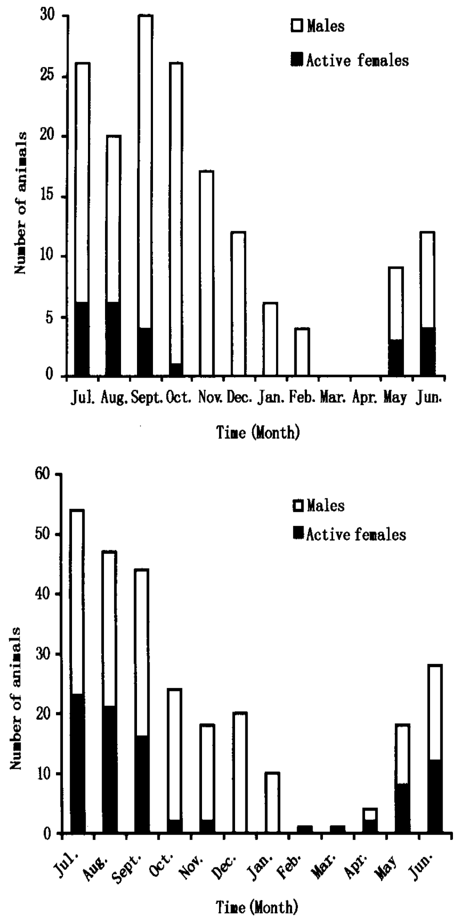

Fig. 6 Sexual activity of common voles in the different genders showing fluctuation during the year and variations between the genders

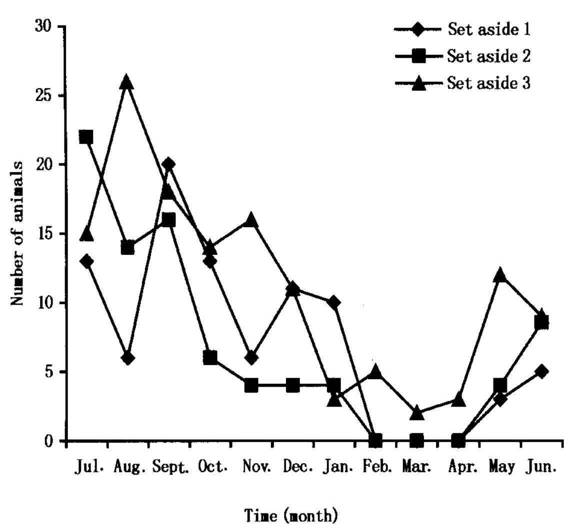

Fig. 7 The annual population dynamics for *Microtus arvalis* (Animal numbers per 150 m^2) (Minimum number alive)

Population density of common voles was lowest in spring, with an increase beginning at the end of May, followed by a decline to an interim low at the beginning of August. Population density increased again until November and then declined to a low in winter.

Home ranges were calculated according to the Minimum Convex Polygon method (MCP) (Mohr, 1947; Worton, 1987). Common voles moved only small distances inside the set aside grid. The home range size of males was 350 m^2 and have 400 m^2 for females. There were no significant differences between males' and females' home range in either year (U-test, $P > 0.05$).

3 Discussion

Three small mammal species were regularly caught in the set asides: the common vole, and the white-toothed shrew, and the wood mouse. Common voles were more abundant at Salavaux and Chevroux than in Montbrelloz set asides. White-toothed shrews were only caught at Chevroux. According to Tattersall *et al.*, (2000), Rogers and Gorman (1995) and Flowerdew (1985) the wood mouse is a more common species in set asides than the common vole, but in our study the common vole was captured more frequently than the wood mouse (Rogers and Gorman, 1995; Ellenbroek, 1998; Tattersall, 2000). This is similar to the results of Ellenbroek *et al.*, (1998). Shrews need ground cover and are frequently live trapped in set asides. But, even as cover increased during spring and summer, shrews were never caught inside the crop fields. Shrews mainly feed on vertebrates, and may have a controlling effect on common vole populations in set asides (Gurnell, 1995). That shrews were restricted to set asides may be the result of better food availability in set asides and difficulties in burrowing. Whenever observed, shrews appeared to be making use of burrows of the common vole. Wood mice also depend on the presence of ground cover (Delattre, 1992). That wood mice were never trapped in set asides may be because food availability; fleshy fruits and seeds and leaves of woody plants, is low in set asides (Jacob and Brown, 2000).

Population densities and fluctuations of small mammals were similar between the three set aside areas. Briner (2002) and Baumann (1996) reported that in wildflower strips the density of common voles was minimal in spring, and the first increase in numbers began at the end of May; after a decline to a brief low at the beginning of August, the population grew again until November, followed by a decline in winter (Baumann, 1996; Briner, 2002). A review of regional studies of the common vole has shown that population fluctuations and outbreaks are closely correlated to land use pattern; thus, landscape composition determines common vole population diffusion and population dynamics (Jacob and Brown, 2000). Our results agree with the above reports. The activity rhythm of common vole seemed to be similar in the three set asides, with animals active day and night. Previous research indicated common voles that inhabit fields and meadows , are active day and night because of the need to consume food throughout the day and night. Alternatively , variation in feeding times of specific predators may result in nocturnal or diurnal activity , depending upon which predators are present in the area (Halle and Lehmann , 1987 ; Jacob , 2003 ; Jacob and Hempel , 2003) . Our observation of the activity pattern of the common vole in the Salavaux very similar to above hypothesis , common vole very active in day ; but common vole activity in the Chevroux and Montbrelloz was dissimilar ; we only captured the animal at night. We assumed that this might be related to factors like predation risk , vegetation cover or food availability.

The sex ratio of common vole in our study sites was similar to that described by Adamczewska (1981) , Adamczewska and Nabaglo (1977) , Baumann (1996) and Briner (2002) . Although there were differences in the proportion of males and females in given set asides , overall we caught more females than males. This was also reported by Baumann (1996) , who studied common vole populations in weed strips. Differences in the age structure of two genders may have been related to differential dispersal. The greater proportion of subadult males may be explained by earlier sexual maturity of females or by emigration of young females into adjacent parts of the set asides or into crop fields. The observation that more adult females than males were captured may be because sexually mature male offspring are not tolerated by their mothers and must disperse. Hence , dispersers would mostly consist of subadult females and sexually mature males. The difference in sex ratio at a certain age could therefore be a result of dispersal of young females , which plays a crucial role in the distribution and abundance of small mammal.

Home range size of small mammals varies depending on landscape characteristics and food availability (Jacob , 2003) . Jacob (2003) used the radio-telemetry to study the home range of common voles in cultivated land. He reported that mean home range size was not different between males (202 m^2) and females (196 m^2) ; Briner (2002) reported that common voles showed only small home ranges , with a median size of 125 m^2 (Minimum convex polygon method , MCP) and 60 m^2 (Kernel method) , the maximum home range length in wildflower strips was between 37. 5 and 52 m. Baumann (1996) found that common voles moved only small distances inside the strips and the observed length of home-range was 40. 01 m. Mackin-Rogalska (1981) found that home range size of common voles was 145 m^2 in alfalfa and pasture (Agrell *et al*. , 1992) . In our study , because of the very low recapture rate of common voles in set asides , we were not able to compare home range sizes between males and females , but according to the movements of a few animals , we could estimate the home range of common voles in Salavaux and Chevroux. We found that the mean home range size of common voles was between 250 and 400 m^2 , which are in agreement with the results of Baumann (1996) and Briner (2002) . We suggest that food resources and predation risk are key factors for determining the home range size of common voles in set aside areas.

Body size is correlated with many ecologically important parameters including population density (Cotgreave and Stockley , 1994 ; Zeng *et al*. , 1996a ; Mahlaba and Perrin , 2003) , survival , predation (Harestad and Bunnell , 1979 ; Zeng *et al*. , 1996b) , home range size ; body size varies within species of small mammals mainly due to variations in body mass. Jacob (2003) studied common vole body weight dynamics in agro-ecosystems and found that body mass fluctuated on all plots seasonally with higher amplitudes for males than females. In our study , we found similar results , there was a significant difference in body mass between the sexes among common voles during all capture periods in set asides , with males being heavier than females (t-test unequal variances : $t = 5.011$, $df = 162$, $P < 0.05$, N = 213) .

References :

Adamczewska A K A. 1981. Population structure of *Microtus arvalis* (Pall.) against the background of a community of rodent in crop fields . *Polish Ecological Studies* , **7** (1) : 193 - 211.

Adamczewska A K A , Nabaglo L. 1977. Demographic parameters and variations in numbers of the common vole . *Acta Theriologica* , **22** (3) : 431 - 457.

Agrell J , Erlinge S , Nelson J , Sandell *M*. 1992. Body weight and population dynamics : cyclic demography in a noncyclic population of the field vole (*Microtus agrestis*) . *Canadian Journal of Zoology* , **70** (4) : 494 - 501.

Baumann L. 1996. The influence of field margins to populations of small mammals - a study of the population ecology of the common vole *Microtus arvalis* in sown weed strips. Diploma thesis , University of Bern.

Barone M , Frank T. 2003. Habitat age increases reproduction and nutritional condition in a generalist arthropod predator. *Oecologia* , **135** (1) : 78 - 83.

Briner T. 2002. Population dynamics , spatial and temporal patterns of the common vole *Microtus arvalis* in a wildflower strips , using mark recapture method and a new system for automatic radio tracking . PhD thesis , University of Bern.

Carlsen M , Lodal J , Leirs H , Jensen T S. 1999. The effect of predation risk on body weight in field vole , *Microtus agrestis*. *Oikos* , **87** (2) : 277 - 285.

Cotgreave P , Stockley P. 1994. Body size , insectivory and abundance in assemblages of small mammals. *Oikos* , **71** (1) : 89 - 96.

Church F S. 1991. The common shrew. In : Corbett G B , Harris S eds. Handbook of British Mammals. London : Blackwell Sciences Publication , Oxford , 51 - 58.

Delattre P , Giraudoux P , Baudry J. 1996. Effect of landscape structure on common vole (*Microtus arvalis*) distribution and abundance at several scales . *Landscape Ecology* , **11** (5) : 279 - 288.

Delattre P , Giraudoux P , Baudry J , Musard P , Toussaint M , Truchetet D. 1992. Land use patterns and type of common vole population kinetics . *Agriculture , Ecosystem & Environment* , **39** (3 - 4) : 153 - 169.

Duelli P , Obrist M K , Schmatz D R. 1999. Biodiversity evaluation in agricultural landscapes : aboveground insects. *Agriculture , Ecosystem & Environment* , **74** (1) : 33 - 64.

Duelli P , Obrist M K. 2003. Regional biodiversity in an agricultural landscape : the contribution of semi-natural habitats islands. *Basic Applied Ecology* , **4** (2) : 129 - 138.

Ellenbroek F , Busy J , Oosterveld E. 1998. Nature-oriented management of set aside land : do mammals benefit ? *Lutra* , **40** (2) : 41 - 56.

Flowerdew J R. 1985. The population dynamics of wood mouse and yellownecked mice. *Symposium Zoology Society of London* , **55** (2) : 315 - 338.

Frank T. 2003. Influence of slug herbivory on the vegetation development in an experimental wildflower strip. *Basic and Applied Ecology* , **4** (1) : 139 - 147.

Frank T , Nentwig W. 1995. Ground dwelling spiders in sown weed strips and adjacent fields. *Acta Oecologica* , **16** (1) : 179 - 193.

Frank T. 1998. The role of different slug species in damage to oilseed rape bordering on sown wildflower strips . *Annals of Applied Biology* , **133** (3) : 483 - 493.

Franois H T , David W M , Will J M. 1997. Small mammals on one-year set aside. *Acta Theriologica* , **42** (3) : 329 - 334.

Gurnell J. 1995. Woodland rodent communities. *Symposium Zoological Society London* , **55** : 377 - 411.

Halle S , Lehmann U. 1987. Circadian activity patterns , photoperiodic responses and population cycles in voles : long term variations in circadian activity patterns . *Oecologia* , **71** (4) : 568 - 572.

Harestad A S , Bunnell F L. 1979. Home range and body weighta reevaluation. *Ecology* , **60** (3) : 389 - 402.

Jacob J , Brown J. 2000. Microhabitat use , giving up densities and temporal activity as short and long term anti predator behavior in common vole. *Oikos* , **91** (1) : 131 - 138.

Jacob J. 2003. Body weight dynamics of common voles in agro-ecosystems. *Mammalia* , **67** (4) : 559 - 566.

Jacob J , Hempel N. 2003. Effects of farming practice on spatial behavior of common voles. *Journal of Ethology* , **21** (1) : 45 - 50.

Krebs C J. 1999. Ecological Methodology. 2nd Edition. California : Benjamin Cummings , Menlo Park.

Krebs C J. 1966. Demographic change in fluctuating population of *Microtus californicus*. *Ecological Monographs* , **36** (2) : 239 - 273.

Lys J A , Nentwig W. 1992. Augmentation of beneficial arthropods by strip management. Surface activity , movements and activity abundance of abundance carabide beetles in a cereal field. *Oecologia* , **92** (3) : 373 - 382.

Mackin R R. 1981. Spatial structure of rodent populations co-occurring in different crop fields. *Polish Ecological Studies* , **7** (2) : 213 - 227.

Mahlaba T A M , Perrin M R. 2003. Population dynamics of small mammals at Mlawula Swaziland. *African Journal of Ecology* , **41** (3) : 317 - 323.

Milton S J , Dean W R J , Klotz S. 1997. Effect of small-scale animal disturbances on plant assemblages of set aside land in central Germany. *Journal of Vegetation Science* , **8** (1) : 45 - 54.

Mohr C O. 1947. Table of equivalent populations of North America small mammals. *American Midland Naturalist* , **37** (1) : 223 - 249.

Montgomery W I , Dowie M. 1993. The distribution and population regulation of the wood mouse *Apodemus sylvaticus* on field boundaries of pastoral farmland . *Journal of Applied Ecology* , **30** (4) : 783 - 791.

Nentwig W. 2003. Management of biodiversity in agro-ecosystems . *Basic and Applied Ecology* , **4** (2) : 105 - 106.

Rogers L M , Gorman M L. 1995. The-population dynamics of small mammals living in set aside and surrounding semi natural and cropland . *Journal of Zoology*. *London* , **236** (4) : 451 - 464.

Tattersall F H , Avundo A E , Manley W J. 2000. Managing set aside for field voles (*Microtus agrestis*) . *Biological Conservation* , **96** (1) : 123 - 128.

Wilson W L , Montgomery W L , Elwood R W. 1993. Population regulation in the mouse *Apodemus sylvaticus*. *Mammal Review* , **23** (2) : 73 - 92.

Worton B J. 1987. A review of models of home range for animal movement . *Ecological Modeling* , **38** (3 - 4) : 277 - 298.

Zejda J , Nesvadbova J. 2000. Abundance and reproduction of the common vole (*Microtus arvalis*) in crop rows and associated agricultural habitats. *Folia Zoologie* , **49** (4) : 261 - 268.

Zeng Z , Ding W , Yang Y , Luo M , Xie R , Dai Y , Song Z. 1996a. Population ecology of *Rattus nitidus* in the western Sichuan plain I. Population dynamics and body mass. *Acta Theriologica Sinica* , **16** (3) : 202 - 210.

Zeng Z , Ding W , Yang Y , Luo M , Xie R , Dai Y , Song Z. 1996b. Population ecology of *Rattus nitidus* in the western Sichuan plain II. Survival and movement. *Acta Therologica Sinica* , **16** (4) : 278 - 284.