



HAL
open science

Capture-recapture study of a population of the Mediterranean Pine vole (*Microtus duodecimcostatus*) in Southern France

G. Guédon, E. Paradis, H Croset

► **To cite this version:**

G. Guédon, E. Paradis, H Croset. Capture-recapture study of a population of the Mediterranean Pine vole (*Microtus duodecimcostatus*) in Southern France. *Mammalian Biology: Zeitschrift für Säugetierkunde*, 1992, 57 (6), pp.364-372. ird-02061421

HAL Id: ird-02061421

<https://ird.hal.science/ird-02061421>

Submitted on 8 Mar 2019

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Capture-recapture study of a population of the Mediterranean Pine vole (*Microtus duodecimcostatus*) in Southern France

By G. GUEDON, E. PARADIS, and H. CROSET

Laboratoire d'Eco-éthologie, Institut des Sciences de l'Evolution, Université de Montpellier II, Montpellier, France

Abstract

Investigated the population dynamics of a *Microtus duodecimcostatus* population by capture-recapture in Southern France during two years. The study was carried out in an apple orchard every three months on an 1 ha area. Numbers varied between 100 and 400 (minimum in summer). Reproduction occurred over the year and was lowest in winter. Renewal of the population occurred mainly in autumn. The population contained erratic individuals which did not take part in the reproduction. Resident individuals had a longer life-span and home ranges always located at the same place. Mean adult body weight varied only among females in relation to the reproductive rate. The observed demography of *M. duodecimcostatus* could be explained by biological traits (litter size, longevity) and by features of the habitat (high and constant level of resources, low level of disturbance), suggesting that social behaviours are an important regulating factor of numbers.

Introduction

The Mediterranean pine vole (*Microtus duodecimcostatus* de Sélys-Longchamps) has a narrow geographic range: Portugal, Spain and Southern France (Niethammer 1982). Its population dynamics in natural habitats is unknown. The Mediterranean pine vole lives also in cultivated areas. Vineyards are very ancient in the Mediterranean Region (several centuries), and the Mediterranean pine vole is abundant in such a habitat though it causes no particular damage. But the culture of perennial plants (e.g. orchards) with summer irrigation transformed the Mediterranean pine vole's habitat in such a way that this rodent species has become a pest to agriculture for a few years (Guédon 1987, 1988). This indicates the potentialities of *Microtus duodecimcostatus* to colonize successfully particular habitats.

A research program conducted by several institutes (Association de Coordination Technique

Agricole, Institut de la Recherche Agronomique, Service de la Protection des Végétaux) was started in 1986. The aim of this program is studying reproductive biology and population ecology of the Mediterranean pine vole, on the one hand, developing an integrated struggle system (a risk foresight method and biological, chemical, physical, mechanical, and agricultural struggle methods based on a good knowledge of the species). We here present demographic data from a study focused on local population dynamics of *Microtus duodecimcostatus* in cultivated areas.

Materials and methods

A capture-recapture study was started in 1989 in Southern France, in an area located 30 km east of Montpellier (43°39' N, 4°11' E). The region is an agroecosystem with intensive cultures distributed in many patches separated by thick boundaries made with shrubs, cypress or poplar. During two years we trapped a population in a 20-year-old apple orchard (Golden Delicious/E.M.9 variety; pollinization is made by branches of other varieties). The main agricultural practices are: cutting and crunching of the branches in winter, regular weeding, chemical treatment by pulverization all along the cultural cycle, chemical manuring. The influence of the Mediterranean climate is partially masked because of summer watering. The main disturbance which occurred during the study was a plough partially breaking up the soil in winter 1989. No chemical treatment against the Mediterranean pine vole was carried out during our study. Presence of this vole is revealed, as this species digs up soil from the ground when it is burrowing.

The trapping procedure for subterranean rodents was developed by Pascal (1984; Pascal and Meylan 1986) for the fossorial form of the Water Vole (*Arvicola terrestris scherman*). This procedure was adapted for snap-trapping (Guédon and Pascal 1992) and for live-trapping of the Mediterranean pine vole (present study). We used Longworth traps (baited with apple) the efficiency of which has previously been demonstrated (Guédon et al. 1990). Traps were distributed on a 1 ha area, along six parallel 5 m X 100 m strips divided into 25 m² squares (Fig. 1). Two trap-stations (when possible) were arranged in each square, each trap-station contained one, two or three traps orientated in the axis of the tunnel previously digged out. Each trap was open during 42 hours, and was checked 7 times. The caught animals were weighed (to the nearest g), marked by toe-clipping and ear-cutting, reproductive conditions (males: testes scrotal or abdominal, females: pregnant, lactating, and vulva open or closed) and coat color were noted before being released. It was also noted whether the trap was covered up with soil by the vole (named "trap-stuffing" by Krebs and Boonstra 1984), which is a typical behaviour of this species when its tunnels are opened. Two age-classes were distinguished according to weight, adult: > 17 g, and juvenile: ≤ 17 g. Strips

were trapped two by two, so a trapping-session lasted 9 days. Trapping-sessions were carried out every 3 months.

Results

Demography

We caught 1,534 animals 4,656 times in 18,818 trap-checks. The observed numbers (Fig. 2) varied according to the seasons, with a decrease during summer droughts. Proportion of juveniles in the population was always low (Fig. 2). Sex ratio of the caught animals never differed from 1:1 (χ^2 -tests), as well for the adults than for the juveniles (Fig. 3, the greater fluctuations observed among the juveniles are caused by their smaller numbers compared to the adults).

Among the 429 individuals caught in February 1989, five were recaptured in February 1991 (3 males and 2 females of which one was pregnant).

Reproductive activity occurred over the year but shows seasonal variations. We exceptionally observed male individuals with testes in scrotal position, indicating that testes position is not a reliable sign of sexual activity in male *M. duodecimcostatus*. The proportion of females sexually active was maximum in May, August and November, but seemed to show inter-annual variations (Fig. 4). This is corroborated by the proportion of juveniles in the population: maximum in August 1989 and in November the following year (Fig. 3). Captures of pregnant females which were also lactating confirmed the existence of post-partum fecundation as was observed in laboratory (Guédon et al. 1991a). The distinction between marked adult females (present for at least 3 months) and the unmarked ones shows the following pattern: the proportion of females with external signs of reproductive activity was always higher among the former than among the latter (Fig. 4). This difference is not always statistically significant (χ^2 -tests).

The variations in mean body weight of the caught voles did not show seasonality (Tab. 1). Mean adult body weight was slightly bigger among females than among males (range: 21.5–24.2, and 20.7–22.1, respectively), due to the presence of pregnant females. Standard deviation of adult body weight was slightly larger among females than among males (range: 1.6–3.0, and 1.4–2.2, respectively); this is probably due to the heterogeneity of pregnancy among the females (Fig. 4).

The proportion of unmarked animals (immigrants, animals born during the three previous months, or residents not previously caught: Fig. 5) varied with the seasons: it was minimum in August and maximum in November, indicating that renewal of the population occurred mainly in autumn.

Individual movements recorded during the study

Despite the low distance between two trapping-strips (20 m), the recapture rates from one strip to another were very low (0.4–16%) indicating that, either movements of the Mediterranean pine vole were very restricted during the time of a trapping-session, or a decrease in the trappability of the voles after a first capture. Analysis of movements between two trapping-sessions corroborates the former explanation: the majority of animals were recaptured at the same place as three months before. Such sedentary animals were observed during several consecutive sessions: among 48 animals caught in four consecutive sessions, 38 (79%) were always located at the same place. Home range locations seem constant over time, however we cannot speculate about variations of home range sizes.

The proportion of animals caught twice or more during the 7 checks (within trapping-session recapture rate) varied with the seasons (Fig. 6), suggesting a decrease in trappability during summer. This proportion was always higher among the marked animals than among the unmarked ones (except August 1989).

Parameters related to the trapping procedure

Trapping-intensity varied slightly with the seasons: minimum in August, and maximum in November (Fig. 7). These variations were related to the lesser number of presence signs on the ground. Proportions of captures and of trap-stuffings (reported on trapping-intensity) varied greatly with the seasons (Fig. 7). The proportion of captures was minimum in August (= 10%) and varied between 20% and 45% for the other sessions, the results of February 1989 (45%) were not obtained again in 1990 and 1991. The proportion of trap-stuffings varied inversely with the proportion of captures.

Other species

Five other species were caught in our traps: *Crocidura russula*, *Apodemus sylvaticus*, *Mus musculus*, *Rattus norvegicus*, and *Mustela nivalis*. Numbers of captures for each species are indicated in Table 2. Herbivorous and granivorous small mammals were scarce in the underground habitat suggesting that competitive interactions with *M. duodecimcostatus* are not important in our study area. Only one weasel (*Mustela nivalis*) was caught, indicating that predation by this species

may not influence the population dynamics of the Mediterranean pine vole in our study area. A domestic cat (*Felis catus*) was observed in the orchard while hunting; however, raptor birds (*Strix aluco*, *Buteo buteo*, *Falco tinnunculus*) were regularly observed and were probably the main predators of the voles.

Discussion

Nearctic and Palearctic Pine vole species are generally all included in the “*Pitymys* group” which is considered as a genus (Honacki et al. 1982; Corbet and Hill 1991) or a subgenus included in the genus *Microtus* (Niethammer and Krapp 1982; Nowak and Paradiso 1983). Chaline et al. (1988) argued that the subgenus *Pitymys* is polyphyletic and proposed to divide it into two subgenera: *Pitymys* (nearctic species) and *Terricola* (palearctic species). If Chaline et al. are right, it would implicate a converging evolution of some characters (particularly life-history traits as we will see below) between *Pitymys* and *Terricola*.

In our population of *M. duodecimcostatus* we observed a decreased trappability during summer. The same phenomenon was observed in *M. pinetorum* (Lindquist et al. 1981; Cornbower and Kirkland 1983) and several *Microtus* species (Krebs and Boonstra 1984). Added to the fact that the proportion of trap-stuffings increased in summer, this leads us to invoke a more subterranean behaviour of the Mediterranean pine vole in order to avoid the hot and dry atmosphere. This changing behaviour may explain the decrease in captured voles during summer, however we cannot exclude a mortality peak during this season.

The age-classes chosen in our study were *ad hoc*: animals less than 18 g weighed more than 17 g three months later. A snap-trapping study demonstrated that some females less than 18 g could be pregnant (Guédon unpubl. data). Body growth may be slower in nature than in captivity (Guédon et al. 1991b). However, the proportions of juveniles were always low. This can be explained by a low trappability of this age-class: voles were not caught before they weigh at least 8 g. Mc Guire and Novak (1984) and Salvioni (1988) observed that behavioural development was slow in juveniles of other Pine vole species (*M. pinetorum* and *M. subterraneus*, respectively). Several studies showed that proportion of juveniles was always low in populations of *M. pinetorum* (Simpson et al. 1979; Lindquist et al. 1981; Cornbower and Kirkland 1983). Fecundity in Pine vole species is low compared with other *Microtus* species or other microtine genera (Lefèvre 1966; Pelikán 1973; Schadler and Butterstein 1979; Salvioni 1986; Guédon et al. 1991a, see Innes 1978 or Keller 1985 for reviews), and may influence the age-structure of the population.

A long life-span was observed in other Pine vole species (Le Louarn 1974; Cornbower and

Kirkland 1983; Salvioni 1986), and seems to be a trait of these microtine species. Some studies suggested that populations of *M. pinetorum* present a high turn-over (Miller and Getz 1969; Staples and Terman 1977; Simpson et al. 1979). Such a pattern is also present in our study; however, preliminar statistical analysis revealed that it was an artifact: most of the unmarked individuals were erratics and were not subsequently recaptured (Paradis 1990).

The fact that reproduction occurs over the year in *M. duodecimcostatus* was also observed in Spain (Claramunt 1976; Palomo et al. 1989), and in populations of *M. pinetorum* living in orchards (Simpson et al. 1979; Cornbower and Kirkland 1983), though this species lives in a cooler climate. Reproduction in our population was minimum during winter, this result is not in agreement with Palomo et al.'s study who showed that reproduction decreased dramatically during summer. This latter result is supported by a small number of caught animals (210 individuals during 2 years and only 4 females in summer), however, and a monthly snap-trapping study in Southern France (more than 7,000 individuals caught during 5 years) showed that reproduction decreased in June and July but increased in August (Guédon and Pascal unpubl. data). Discrepancy between the results of the two approaches (snap-trapping and live-trapping) can be explained by the fact that pregnancy cannot be detected on living voles before about 10 days, but can be detected at about 6 days in necropsy samples (Keller 1985). Cohen-Shlagman et al. (1984) observed a decreased reproductive activity in summer in *Microtus guentheri*, another Mediterranean microtine species. The seasonal variations of reproduction observed in our population could be explained by high summer survival of resident individuals due to high level of resources in underground habitat in apple orchards. This hypothesis could be tested by studying seasonal variations of reproduction in uncultivated habitats.

In the studied habitat, food is abundant and uniformly distributed, therefore reproduction is probably conditioned by available space (possibility to construct a burrow). In a population with sustained high densities, space is probably a limiting factor for access to reproduction (at least for females). This assumption is strengthened by the fact that reproductive females are resident (present for at least three months). Social behaviours were evidenced to mediate access to reproduction in many species of mammals (Hendrichs 1983; Dunbar 1985; Armitage 1987). Such a phenomenon may play a role in the local population dynamics of *M. duodecimcostatus*.

Acknowledgements

We thank Jean-Marc Duplantier, Pierre Delattre, Michel Pascal for their comments on an early draft of the manuscript, Nick Court for correcting English, Serge Legendre and an anonymous reviewer for the German translation of the abstract, and François Catzefflis for encouraging us. We are

indebted towards Mr. Giammatei for allowing us to work on his property. We also thank various people for their assistance on the field. This work was financially supported by the FNCA, and a CIFRE grant.

Zusammenfassung

*Markierungsfangstudien an einer Population der Mittelmeer-Kleinwühlmaus (*Microtus duodecimcostatus*) in Südfrankreich*

Eine Population der Mittelmeer-Kleinwühlmaus (*Microtus duodecimcostatus*) wurde in Südfrankreich über einen Zeitraum von 2 Jahren durch Fang, Markieren und Wiederfang untersucht. In Abständen von 3 Monaten wurden Fängen in einem Apfelpfad auf einer Fläche von 1 ha durchgeführt. Pro Fangtermin wurden 100 bis 400 Individuen gefangen, am wenigsten im Sommer. Die Reproduktion fand das ganze Jahr über statt, was aber im Winter am geringsten. Eine Erneuerung der Population fand insbesondere im Herbst statt. Einzelne Individuen nahmen nicht an der Fortpflanzung teil. Seßhafte Individuen hatten eine längere Lebensdauer und ihr Aktionsraum blieb sehr konstant. Das Durchschnittsgewicht variierte nur bei Weibchen in Anhängigkeit von der Reproduktionsrate. Die beobachtete Demographie von *M. duodecimcostatus* kann durch biologische (Wurfgröße, Lebensdauer) und ökologische Merkmale (hohes und regelmäßiges Nahrungsangebot, geringes Störungsniveau) erklärt werden und weist darauf hin, daß das Sozialverhalten ein wichtiger Regulationsfaktor für die Populationsgröße sein könnte.

References

- ARMITAGE, K. B. (1987): Social dynamics of mammals: reproductive success, kinship and individual fitness. *Trends Ecol. Evol.* 2, 279-284.
- CHALINE, J.; BRUNET-LECOMTE, P.; GRAF, J.-D. (1988): Validation de *Terricola Fatio*, 1867 pour les Campagnols souterrains (Arvicolidae, Rodentia) paléarctiques actuels et fossiles. *C. R. Acad. Sci., Paris, Sér. III* 306, 475-478.
- CLARAMUNT, P. T. (1976): Sobre la actividad sexual de *Pitymys duodecimcostatus* de Sélvs-Longchamps, 1839, en Cataluña. *P. Dept. Zool.* 1, 47-54.
- COHEN-SHLAGMAN, L.; YOM-TOV, Y.; HELLWING, S. (1984): The biology of the Levant vole, *Microtus guentheri* in Israel. I. Population dynamics in the field. *Z. Säugetierkunde* 49, 135-147.

- CORBET, G. B.; HILL, J. E. (1991): A world list of mammalian species (3rd Ed.). Natural History Museum Publ., Oxford University Press.
- CORNBOWER, T. R.; KIRKLAND, G. L., Jr. (1983): Comparisons of pine vole (*Pitymys pinetorum*) populations from orchards and natural habitats in southcentral Pennsylvania. Proc. Pa. Acad. Sci. 57, 147-154.
- DUNBAR, R. I. M. (1985): Population consequences of social structure. In: Behavioral ecology: ecological consequences of adaptive behaviour. Ed. by R. M. SIBLY, R. H. SMITH. Oxford: Blackwell Scientific Publications, 507-519.
- GUEDON, G. (1987): Influences de diverses spéculations et pratiques culturelles sur certains paramètres de la cinétique de populations de campagnols à douze côtes, *Pitymys duodecimcostatus* (de Séllys- Longchamps, 1839) dans le Montpellierais (France). D.E.A. report, Univ. Montpellier II.
- GUEDON, G. (1988): Cinétique de population de *Pitymys duodecimcostatus* dans le Montpellierais (France). Bull. OEPP 18,453-461.
- GUEDON, G.; BELAIR, M.; PASCAL, M. (1990): Comparaison de l'efficacité de cinq pièges non vulnérants à l'égard de la capture du Campagnol provençal (*Pitymys duodecimcostatus* de Séllys-Longchamps, 1839). Mammalia 54, 137-145.
- GUEDON, G.; PASCAL, M. (1992): Eléments de validation d'une méthode d'échantillonnage linéaire standardisée adaptée au Campagnol provençal (*Pitymys duodecimcostatus*, de Séllys-Longchamps, 1839). Rev. Ecol. (Terre Vie) 47, 85-102.
- GUEDON, G.; PASCAL, M.; MAZOUIN, F. (1991a): Le campagnol provençal en captivité (*Pitymys duodecimcostatus* de Séllys-Longchamps, 1839) (Rongeurs, Microtidés) I. La reproduction. Mammalia 55, 97-106.
- GUEDON, G.; PASCAL, M.; MAZOUIN, F. (1991b): Le campagnol provençal en captivité (*Pitymys duodecimcostatus* de Séllys-Longchamps, 1839) (Rongeurs, Microtidés) II. La croissance. Mammalia 55, 397-406.
- HENDRICH, H. (1983): On the evolution of social structure in mammals. In: Advances in the study of mammalian behavior. Ed. by J. F. EISENBERG, D. G. KLEIMAN. Spec. Publ. Amer. Soc. Mammal. 7, 738-750.
- HONACKI, J. H.; KINMAN, K. E.; KOEPL, J. W. (1982): Mammal species of the world: a taxonomic and geographic reference. Lawrence, Kansas: The Association of Systematics Collections, Allen Press, Inc.
- INNES, D. G. L. (1978): A reexamination of litter size in some North American microtines. Can. J. Zool. 56, 1488-1496.

- KELLER, B. L. (1985): Reproductive patterns. In: Biology of New World Microtus. Ed. by R. H. TAMARIN. Spec. Publ. Amer. Soc. Mammal. 8, 725-778.
- KREBS, C. J.; BOONSTRA, R. (1984): Trappability estimates for mark-recapture data. Can. J. Zool. 62, 2440-2444.
- LEFEVRE, C. (1966): Etude de la croissance en élevage de *Pitymys duodecimcostatus* de Sélys-Longchamps originaires du Gard. Mammalia 30, 56-63.
- LE LOUARN, H. (1974): Etude par marquage et recaptures du campagnol des champs et du campagnol de Fatio en montagne. Mammalia 38, 54-63.
- LINDQUIST, S. B.; TIPTON, A. R.; YARROW, G. K.; HASBROUCK, J. J. (1981): Analysis of seasonal dynamics of pine vole populations in two Virginia orchards. In: Proceedings of the fifth eastern pine and meadow vole symposium. Ed. by R. E. BYERS. Gettysburg, PA, March 4-5, 1981, 79-83.
- McGUIRE, B.; NOVAK, M. (1984): A comparison of maternal behaviour in the meadow vole (*Microtus pennsylvanicus*), prairie vole (*M. ochrogaster*) and pine vole (*M. pinetorum*). Anim. Behav. 32, 1132-1141.
- MILLER, D. H.; GETZ, L. L. (1969): Life-history notes on *Microtus pinetorum* in central Connecticut. J. Mamm. 50, 777-784.
- NIETHAMMER, J. (1982): *Microtus duodecimcostatus* (de Sélys-Longchamps, 1839) - Mittelmeer-Kleinwühlmaus. In: Handbuch der Säugetiere Europas (Band 2/I, Nagetiere II). Ed. by J. NIETHAMMER, F. KRAPP. Wiesbaden: Akademische Verlagsgesellschaft, 463-475.
- NIETHAMMER, J.; KRAPP, F. (eds) (1982): Handbuch der Säugetiere Europas (Band 2/I, Nagetiere II). Wiesbaden: Akademische Verlagsgesellschaft.
- NOWAK, R. M.; PARADISO, J. L. (1983): Walker's Mammals of the world (4th Ed.). The John Hopkins University Press.
- PALOMO, L. J.; VARGAS, J. M.; ANTÚNEZ, A. (1989): Reproduction de *Microtus (Pitymys) duodecimcostatus* (de Sélys-Longchamps, 1839) (Mammalia, Rodentia) dans le sud de l'Espagne. Vie et Milieu 39, 153-158.
- PARADIS, E. (1990): Démographie d'une population de campagnol provençal (*Pitymys duodecimcostatus*): hypothèses sur les mécanismes de régulation en milieu anthropisé. D.E.A. report, Univ. Montpellier II.
- PASCAL, M. (1984): Méthode d'échantillonnage d'un rongeur souterrain, la forme fouisseuse du campagnol terrestre (*Arvicola terrestris scherman*). Recherche des limites d'utilisation de la méthode. Acta Oecologica/Ecol. Applic. 5, 303-317.

- PASCAL, M.; MEYLAN, A. (1986): L'échantillonnage linéaire des populations de la forme fouisseuse du campagnol terrestre (*Arvicola terrestris scherman* [Shaw]). Description des techniques. La Défense des Végétaux 237, 3-12.
- PELIKÁN, J. (1973): Notes on the reproduction of *Pitymys subterraneus* (de Sél. Long.). Zoologické Listy 22, 285-296.
- SALVIONI, M. (1986): Domaines vitaux, relations sociales et rythmes d'activité de trois espèces de *Pitymys* (Mammalia, Rodentia). Ph.D. dissertation, Univ. of Lausanne.
- SALVIONI, M. (1988): Rythmes d'activité de trois espèces de *Pitymys*: *Pitymys multiplex*, *P. savii*, *P. subterraneus* (Mammalia, Rodentia). Mammalia 52, 483-496.
- SCHADLER, M. H.; BUTTERSTEIN, G. M. (1979): Reproduction in the pine vole, *Microtus pinetorum*. J. Mamm. 60, 841-844.
- SIMPSON, D. A.; ANTHONY, R. G.; KELLY, G. M.; STORM, G. L. (1979): Dynamics of a pine vole population in a Pennsylvania orchard. In: Proceedings of the third eastern pine and meadow vole symposium. Ed. by R. E. BYERS. New Paltz, N.Y., February 14-15, 1979, 47-51.
- STAPLES, P. P.; TERMAN, C. R. (1977): An experimental study of movement in natural populations of *Mus musculus*, *Microtus pennsylvanicus*, and *Microtus pinetorum*. Res. Popul. Ecol. 18, 267-283.

Authors' addresses: G. GUEDON, Délégation régionale ACTA, Maison de l'Agriculture de Vendée, Boulevard Réaumur, F-85013 La Roche-sur-Yon cédex, France; E. PARADIS and H. CROSET, Laboratoire d'Eco-éthologie, Institut des Sciences de l'Evolution, Case Courrier 64, Université de Montpellier II (U.S.T.L.), Place Eugène Bataillon, F-34095 Montpellier cédex 5, France

Table 1. Mean body weight of the caught voles in each trapping-session (mean \pm standard deviation)

session		Feb 89	May 89	Aug 89	Nov 89	Feb 90	May 90	Aug 90	Nov 90	Feb 91
adults	males	22.1 \pm 2.2	21.8 \pm 1.8	21.1 \pm 1.9	21.1 \pm 1.8	21.1 \pm 1.7	20.7 \pm 1.7	21.5 \pm 1.7	21.0 \pm 1.9	20.6 \pm 1.4
	females	23.0 \pm 2.8	23.3 \pm 3.0	23.6 \pm 1.8	22.4 \pm 2.4	21.5 \pm 2.1	22.0 \pm 2.8	24.2 \pm 1.6	21.8 \pm 2.2	21.4 \pm 2.3
juveniles	males	14.9 \pm 2.2	14.9 \pm 2.0	15.2 \pm 2.1	13.4 \pm 2.0	15.0 \pm 2.0	14.8 \pm 2.0	13.3 \pm 2.3	14.4 \pm 2.0	17.0 \pm 0.0
	females	14.9 \pm 2.3	14.2 \pm 2.2	14.1 \pm 2.4	15.3 \pm 1.6	14.4 \pm 2.3	14.4 \pm 2.4	13.8 \pm 1.9	14.7 \pm 2.3	15.5 \pm 2.6

Table 2. Numbers of captures for other species in the Longworth traps disposed in the underground habitat of *M. duodecimcostatus*

species	Feb 89	May 89	Aug 89	Nov 89	Feb 90	May 90	Aug 90	Nov 90	Feb 91
<i>Crocidura russula</i>								1	
<i>Apodemus sylvaticus</i>	8	6	2	1	2			2	1
<i>Mus musculus</i>								1	
<i>Rattus norvegicus</i>					1				
<i>Mustela nivalis</i>			1						

Fig. 1. Arrangement of the traps on the study area. In each square two, one, or no trap-station(s) were arranged in relation to the number of presence signs of Mediterranean pine vole on the ground. Each trap-station contained one, two or three traps.

Fig. 2. Total number of caught voles (curve) and percentage of the two age-classes (histogram) during two years.

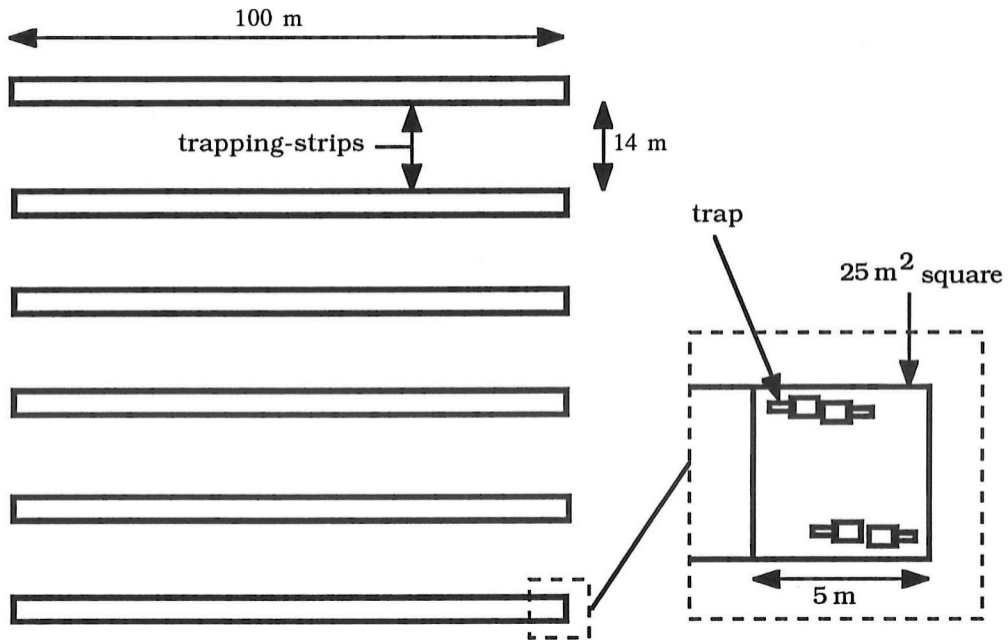
Fig. 3. Sex ratio of the juveniles (voles less than 18 g), the adults (voles more than 17 g), and the whole caught voles (juveniles and adults).

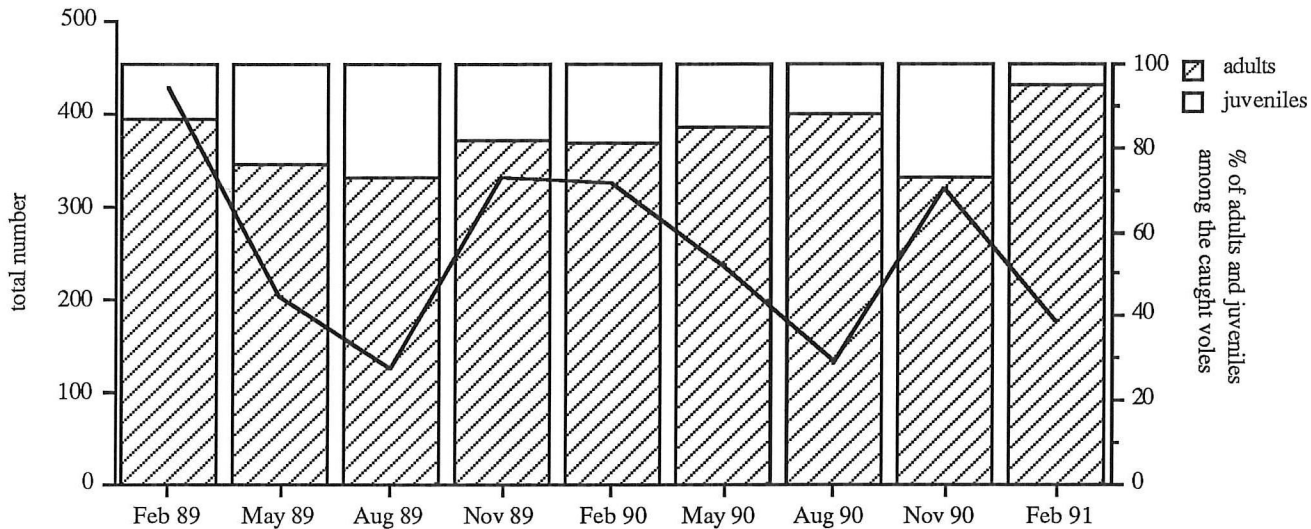
Fig. 4. The adult females caught during each trapping-session are divided in two categories: the marked ones and the unmarked ones (the caught numbers of each category are indicated). The proportion of individuals with external signs of sexual activity for each category are plotted and compared (χ^2 -tests, * $0.01 < p < 0.05$; ** $0.001 < p < 0.01$; *** $p < 0.001$).

Fig. 5. Proportions of marked voles and unmarked voles caught in each trapping-session.

Fig. 6. Comparison of the proportion of voles caught at least twice during the 7 checks (within trapping-session recapture rate) between the marked voles and the unmarked ones.

Fig. 7. Trapping-intensity (expressed as number of trap-checks: left axis) and trapping-results (number of captures and number of trap-stuffings reported to the number of checks: right axis) in each trapping-session.





sexratio

