

## ESTIMATING THE RELATIVE ABUNDANCE AND TEMPORAL ACTIVITY PATTERNS OF WOOD MICE (*Apodemus sylvaticus*) BY REMOTE PHOTOGRAPHY IN MEDITERRANEAN POST-FIRE HABITATS

I. TORRE<sup>1</sup>, A. PERIS<sup>2</sup> AND L. TENA<sup>3</sup>

1. Museu de Granollers-Ciències Naturals. Francesc Macià 51. E-08400 Granollers (Barcelona).  
(i.torre@museugranollers.org)
2. Av. 316, nº 9, E-08860 Castelldefels, (Barcelona).
3. Madriguera nº1, 1º, E-08870 Sitges, (Barcelona).

### ABSTRACT

We investigated whether remote photography can be considered a valid method to assess the abundance and the temporal activity patterns of the wood mouse (*Apodemus sylvaticus*) in two Mediterranean post-fire habitats. We compared the results with those obtained by Sherman live-trapping, a conventional procedure to obtain information on the composition of small mammal communities. We observed a highly significant increase of abundance of wood mice in shrublands (early post-fire stage) in front of pinewoods (unburned during the last 50 years) with both capture methods ( $G = 104.83$ ;  $p < 0.0001$ ; d.f. = 1). 81 out of 95 photographic contacts of wood mouse were recorded in shrublands (85.3%) and the remainder 14 contacts in pinewoods (14.7%), and 78 out of 90 captures with Sherman traps were obtained in shrublands (86.7%), and the remainder 12 in pinewoods (13.3%). Remote photography showed the same proportions of captures than live-trapping in the two habitats studied ( $G = 0.07$ ;  $p = 0.79$ ; d.f. = 1). Temporal activity patterns of wood mice were biphasic during winter in shrublands, with lower values of activity near sunset and sunrise, and maximum four hours after sunset and five hours before sunrise. We conclude that remote photography, despite pseudoreplication (impossibility to differentiate individuals in the photographs), can be considered a valid method to estimate wood mice abundance and activity patterns in the post-fire habitats studied.

Key words: Activity patterns, *Apodemus sylvaticus*, post-fire habitats, remote photography, Sherman live-trapping, wood mouse

### RESUMEN

*Estima de la abundancia relativa y los patrones de actividad del ratón de campo (Apodemus sylvaticus) mediante trampeo fotográfico en ambientes Mediterráneos post-incendio*

Se investiga si el trampeo fotográfico es un método válido para conocer los patrones de abundancia y actividad de los micromamíferos en dos ambientes Mediterráneos post-incendio. Comparamos los resultados con los obtenidos mediante el trampeo en vivo con Sherman, un método convencional para obtener información sobre la composición de las comunidades de

micromamíferos. Se observó un incremento de la abundancia en los ambientes arbustivos (etapa temprana de la sucesión post-incendio) frente a los pinares (no quemado en los últimos 50 años) con ambos métodos ( $G = 104,8$ ;  $p < 0,0001$ ; g.l. = 1). 81 de los 95 contactos fotográficos de ratón de campo se obtuvieron en los ambientes arbustivos (85,3%) y los 14 restantes en pinares (14,7%), y 78 de las 90 capturas con Sherman se obtuvieron en los ambientes arbustivos (86,7%), y las 12 restantes en pinares (13,3%). El trapeo fotográfico y el trapeo con Sherman mostraron idénticas proporciones de captura en los dos hábitats estudiados ( $G = 0,07$ ;  $p = 0,79$ ; g.l. = 1). El patrón temporal de actividad fue bifásico en invierno en los ambientes arbustivos, con valores mínimos de actividad cerca de la salida y la puesta de sol, con máximos cuatro horas después de la puesta y cinco horas antes de la salida del sol. Se concluye que el trapeo fotográfico, a pesar de la pseudoreplicación (imposibilidad de diferenciar a cada individuo en las fotografías), es un método válido para estimar los patrones de abundancia y actividad de los ratones de campo en los ambientes post-incendio estudiados.

Palabras clave: *Apodemus sylvaticus*, hábitats post-incendio, patrones de actividad, ratón de campo, trapeo fotográfico, trapeo con Sherman

## INTRODUCTION

The wood mouse (*Apodemus sylvaticus*) is a widely distributed generalist rodent that has been the subject of numerous studies regarding many aspects of its biology and ecology (see Flowerdew et al. 1985, and references therein). Nonetheless, most of these studies have been conducted in the northern part of its distribution range (i.e., Northern Europe), and several aspects of wood mouse biology and ecology still remain unknown in the Mediterranean basin (but see Sans-Coma and Gosàlbez 1976, Moreno and Kufner 1988, Fons and Saint-Girons 1993, Prodon et al. 1987, Díaz et al. 1999). Mediterranean environments are characterised by landscape heterogeneity, with recurrent fires and intense agriculture practices being the most influential factors modelling those landscapes (Blondel and Aronson 1999). The wood mouse is common in post-fire habitats (Fons et al. 1988), but its abundance is limited by the habitat quality features at different post-fire stages (Torre and Díaz 2004). Changes in vegetation cover and predation risk as the post-fire succession advances have been suggested as main factors affecting patterns of abundance (Torre and Díaz 2004). Furthermore, predation risk can alter the activity patterns of small mammal preys, by promoting shifts in spatial and temporal use of habitats and microhabitats (Kotler et al. 1994, Morris and Davidson 2000).

Activity patterns of wood mice have been studied by a wide range of techniques (see Montgomery and Gurnell 1985, Corp et al. 1997, and references therein). One of the most successful methods is radiotelemetry, showing that significant differences in activity patterns between compared habitats were mainly

related to habitat quality features (ie, food availability: Zubaid and Gorman 1996, Corp et al. 1997). Nevertheless, this method is time-consuming and expensive when compared with other techniques. Live-trapping with regular trap inspection has also been used to determine temporal activity patterns of wood mice (ie, Kikkawa 1964, Halle 1988), but this method is limited by the number of trapping checks conducted at night, which in turns may disturb the natural activity of mice (Bruseo and Barry 1995). Remote photography is a less invasive and less labor-intensive technique to monitor animal activity (Carthew and Slater 1991, Cutler and Swann 1999), which has been used in studies dealing with spatio-temporal distribution and habitat selection of medium-sized mammals (Foresman and Pearson 1999, Otani 2001), and in studies on diel activity patterns and demography of small mammals (Osterberg 1962, Ylönen 1988, Pei 1995). However, this technique has not been extensively applied to rodents (Cutler and Swann 1999), and, as far as we know, this technique has not been used to study the spatio-temporal distribution of wood mice (see Carley et al. 1970, Barry et al. 1989, and Hicks et al. 1998, for studies on temporal activity patterns of the New World wood mice, *Peromyscus* sp.).

In this paper we propose remote photography as an alternative technique to the study of spatial abundance and temporal activity patterns of wood mice, by comparing the results obtained with a conventional procedure (Sherman live-trapping) in two contrasting habitats differing in the time elapsed since the last fire. We compared shrubland (burned in 1994, seven years after the last fire) with pinewood (unburned at least during the last 50 years). Since both habitats represent significant differences in habitat quality (i.e., in vegetation structure, predation risk, and predation pressure, Torre and Díaz 2004), differences in wood mice abundance and temporal activity patterns between habitats can be expected. We expected higher wood mice abundance in shrublands following the hypotheses presented elsewhere (Torre and Díaz 2004).

## MATERIAL AND METHODS

Field work was carried out in the Garraf Natural Park (1°52'E, 41°17'N; Barcelona province, NE Spain) from September 2001 to February 2002. The natural vegetation of the Park consists of coastal maquis of *Quercus coccifera* and *Chamaerops humilis* and coastal Holm oak forests (*Viburno-Quercetum ilicis*), which are dominated by fire-adapted plant species (resprouters after fire, such as *Quercus coccifera*, *Q. ilex*, *Arbutus unedo*, *Pistacia lentiscus* or *Erica arborea*, or obligate seeders with enhanced germination after fire, such as *Pinus halepensis* and *Cistus* sp.; Naveh 1974). Due to fire recurrency, most current plant communities

in the study area are in a transitional stage, as indicated by the widespread presence of shrublands in relation to forests (80% and 14% of the surface of the Natural Park surface, respectively; Moltó et al. 2003).

We selected two contrasting habitats differing in composition and structure of vegetation: post-fire shrublands (burned in 1994) dominated by scattered resprouting *Quercus coccifera* and *Pistacia lentiscus* shrubs, and pinewoods dominated by old-growth *Pinus halepensis* and scattered *Quercus ilex*. In every habitat we established a grid of 36 compact photographic cameras with baiting stations (6 rows x 6 columns, 250 m between cameras), covering a minimum area of 1.56 km<sup>2</sup>, computed as the surface delimited by the farthest cameras located at the four corners of each plot. Due to cameras availability and man-power limitations, every plot was sampled within two or three months, rotating the stations every week to cover all the surface area (see Martorello et al. 2001, for a similar approach): the pinewood grid was set between early September and late November 2001, and the shrubland grid was set between late December 2001 and late February 2002. This trapping design, at a higher spatial and temporal scale than would be usual for small mammals, was performed to analyse spatial and temporal patterns of use of the sampling stations in common genets (*Genetta genetta* Linnaeus, 1758) (Torre et al. submitted). Otherwise, a high number of photographic contacts were obtained for the wood mouse, and we considered the possibility of testing this method as an alternative to live-trapping (see Hicks et al. 1998, for a similar approach). Every station consisted in a compact camera (Ricoh 35R date) and a remote sensor (infrared beam), and was baited with tuna in oil. Cameras dated each photograph to the nearest minute and were operating continuously during seven consecutive days. The sensor and the bait were located in a small area (2 m<sup>2</sup>) free of vegetation to avoid interference with bushes and herbs, and the camera was focussed at the baiting station from a small tripod where it was set. We used individual foraging bouts as the sample units to analyse spatial and temporal patterns of use of the sampling stations (Hicks et al. 1998). This approach may fall into pseudoreplication due to the impossibility of identifying different individuals in the photographs, and the same individual could be trapped several times along one night or along the complete photographic session (see Cutler and Swann 1999 for discussion on that topic). Nevertheless, the long distance between cameras prevented spatial pseudoreplication, and we considered that camera stations were independent at the spatial scale of small mammals. We defined a photographic contact as a photographic series produced by the same individual or group of individuals when successive photographs were separated by less than five minutes (see Hicks et al. 1998, and Otani 2001, for similar approaches).

In the same vegetative communities where the camera stations were set, we established six independent live-trapping plots consisting in eight Sherman live-traps arranged in pairs and spaced about 5 meters to avoid trap saturation, which were located every 15 m along a straight line (Torre and Díaz 2004). Traps were baited with a mixture of tuna, flour and oil, and were set under the cover of shrubs or dense herbs to conceal them, and cotton fiberfill was used to provide thermal insulation. Traps were open during three consecutive nights and checked every morning. The small mammals caught were identified to species, marked with fur clipping, and released at the point of capture (Gurnell and Flowerdew 1990). The six plots in pinewoods were operating during 24-26 October 2001 and 8-10 January 2002, and the six plots in shrublands during 24-26 October 2001 and 12-14 January 2002.

Distance between Sherman trapping plots and camera plots were relatively short in the case of post-fire shrublands (2 km), and significantly larger in the case of mature pinewoods (9 km). This large distance was a consequence of the reduced surface and high fragmentation of mature pinewoods which occupy 5% of the natural park, mainly in the periphery (Riera 2003), which prevented closer situation of plots.

To have a more appropriate comparison between methods (remote photography versus live-trapping) we used only photographic contacts obtained in camera stations that were operating at the same date than live-trapping plots (Hicks et al. 1998). Since only two cameras in shrublands were operating within the same week than live-trapping plots, and in order to increase and equalize sample size between habitats, we included camera stations that were operating within two or three weeks around the live-trapping date. We selected the data obtained from eight camera stations that were operating between the second and third week of October 2001 in pinewoods (no data between the fourth week of October and the first of November were available), and from eight camera stations that were operating between the first and third week of January of 2002 in shrublands.

We compared photographic contacts to total captures in Sherman live-trapping (including recaptures), since we assumed that both represented biased estimates of abundance (including pseudoreplication). To compare proportions of the different species between habitats and methods we pooled data from the six live-trapping plots and the eight camera stations to reduce low frequencies in some cells (Hicks et al. 1998).

To have an estimate of activity patterns in the two habitats-seasons we used data obtained from the 36 camera stations used in every habitat. In order to search for temporal patterns of activity during the night photographic contacts were pooled at hourly intervals and converted into hours past sunset to study

temporal activity patterns in both habitats (see Bruseo and Barry 1995, and Hicks et al. 1998, for a similar approach), and the time of sunset and sunrise in every habitat-season was considered (see Wolton 1983 for a similar approach). Comparisons between habitats and methods, were made by log-likelihood ratio G-tests (Zar 1996).

## RESULTS

In January, 81 contacts and 130 photographs of wood mice were recorded in shrubland, and in October, 14 contacts and 14 photographs were recorded in pinewood. In January, Sherman live-trapping in shrublands reported 47 different individuals of wood mice that were trapped 78 times, and in pinewoods 30 individuals were trapped 49 times. In October, 51 individuals were trapped 70 times in shrublands, and in pinewoods, six wood mice were trapped 12 times. We detected a highly significant increase of abundance of wood mice in shrublands (early post-fire stage) in front of pinewoods (unburned during the last 50 years) with both capture methods (habitat-season:  $G = 104.83$ ;  $p < 0.0001$ ; d.f. = 1). 81 out of 95 photographic contacts of wood mouse were recorded in shrublands (85.3%) and the remainder 14 contacts in pinewoods (14.7%), and 78 out of 90 captures were obtained in shrublands (86.7%), and the remainder 12 in pinewoods (13.3%). Remote photography showed the same proportions of captures than live-trapping in the two habitats studied (method x habitat-season:  $G = 0.07$ ;  $p = 0.79$ ; d.f. = 1; Figure 1).

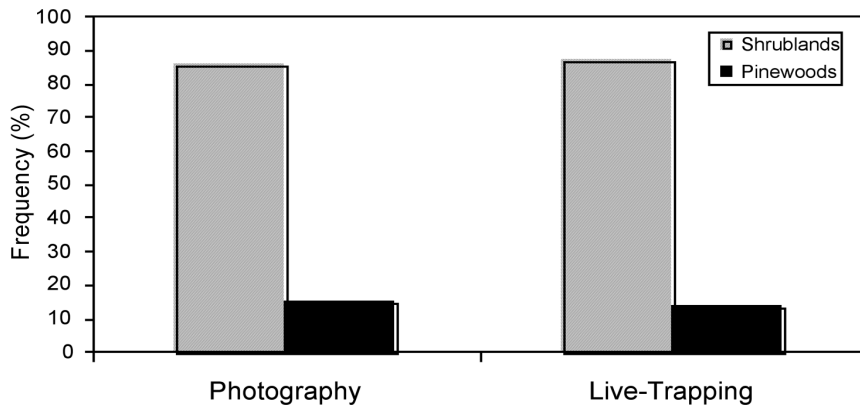


Figure 1. Relative frequency of wood mouse (*Apodemus sylvaticus*) captured by remote photography (100%) and Sherman live-trapping (100%) in two habitats studied.

*Frecuencia relativa de captura del ratón de campo (Apodemus sylvaticus) mediante trampeo fotográfico (100%) y trampeo con Sherman (100%) en los dos hábitats estudiados.*

In order to assess whether changes in wood mice abundance were mainly related to habitat features or to seasonality, we investigated seasonal variation in wood mice captures with Sherman live-trapping. A repeated measures ANOVA pointed out that wood mice variation in relative abundance along the study period was mainly related to habitat, with higher abundance in shrublands ( $F = 83.27$ ;  $p < 0.0001$ ;  $d.f. = 1$ ), and in second term to seasonality, with higher abundance in January ( $F = 13.46$ ;  $p = 0.004$ ;  $d.f. = 1$ ).

In shrubland, 369 out of 407 photographs (90.6%) showed one individual wood mouse, 35 photographs showed two individuals (8.6%), and only three photographs showed three individuals (0.7%). In pinewood, 88 out of 91 photographs showed one individual (96.7%), 3 photographs showed two individuals (3.3%), and none showed three individuals. The proportions observed were not different between habitats (number  $\times$  habitat-season:  $G = 2.65$ ;  $p = 0.26$ ;  $d.f. = 2$ ).

Temporal activity patterns of wood mice were biphasic in shrubland during winter ( $n = 249$  photographic contacts), with minimum activity at sunset and sunrise, and two maximums, one four hours after sunset (between 20-21 hours) and the other five hours before sunrise (between 1-2 hours, Figure 2). The temporal activity patterns of wood mice in pinewood seemed to be polyphasic. Nonetheless, the low frequencies of occurrence of wood mice in pinewood ( $n = 46$  photographic contacts) prevented a valid interpretation of that pattern. Comparison of temporal activity patterns between habitats-seasons at hourly intervals did not show significant differences ( $G = 14.98$ ;  $p = 0.30$ ;  $d.f. = 13$ ).

## DISCUSSION

Remote photography can be considered as a valid and alternative method to estimate wood mice abundance and activity patterns along the post-fire succession. Despite potential pseudoreplication associated to remote photography (due to the impossibility of individual identification), we considered it to be of minor importance since it did not affect detected proportions of wood mice between habitats or seasons, and similar proportions were detected by live-trapping. In this sense, remote photography revealed the increased abundance of wood mice in shrublands when compared with pinewoods, and an identical pattern was recorded for live-trapping (see Torre and Díaz 2004 for similar results with live-trapping in the area during 1999). Nonetheless, our sampling design confounded the effects of habitat and season in the camera plots, since both habitats were sampled in different seasons (fall and winter, respectively). However, live-trapping in both seasons and both habitats showed that differences in habitat quality features rather than seasonality would be responsible of this pattern of

abundance. Early post-fire habitats can be considered favourable to wood mice due to a combination of reduced predation risk (high vegetation cover) and reduced predation pressure (less predators). These results are in close agreement with those obtained in previous studies that hypothesised a role for predation on small mammal abundance changes along the post-fire succession (Torre and Díaz 2004).

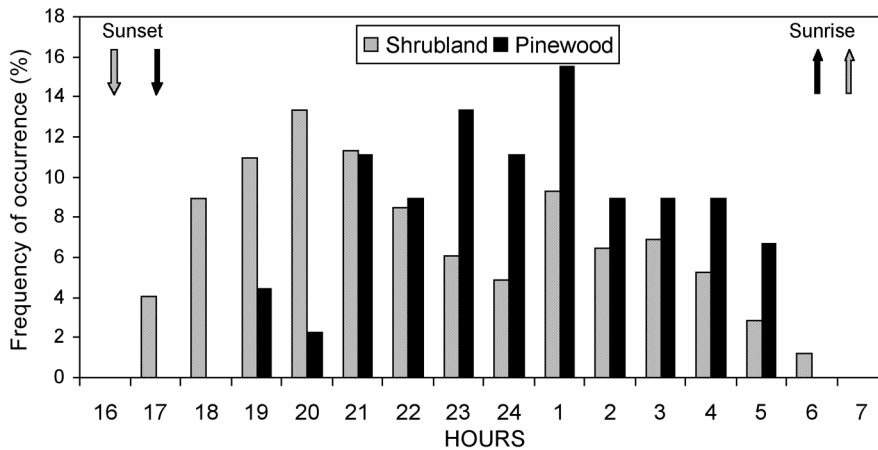


Figure 2. Distribution of photographic contacts of wood mice throughout the night in the two habitats studied (shrublands: n = 249 contacts; pinewoods: n = 46 contacts). Arrows indicate the approximate time of sunset and sunrise in every habitat-season.

*Distribución de los contactos fotográficos de ratón de campo a lo largo de la noche en los dos hábitats estudiados (ambientes arbustivos: n = 249 contactos; pinares: n = 46 contactos). Las flechas indican aproximadamente la salida y puesta de sol en cada ambiente y estación.*

Wood mice in the photographs showed postures related to the investigation of the new structures present in their territories, touching, smelling and climbing-on (Montgomery and Gurnell 1985) the infrared sensor. We detected communal feeding at baiting stations, with two and three individuals exploring or feeding at the baiting stations simultaneously. This phenomenon was also described by Garson (1975) and Lambin (1988), but the proportion of two and three individual records was very much reduced in our study. Wood mice were predominantly nocturnal (Zubaid and Gorman 1996), since no photograph was recorded during the day (some near sunset and sunrise). Temporal activity patterns of wood mice were biphasic during winter in shrublands, with lower values of activity near sunset and sunrise, and maximums four hours after sunset and five hours before sunrise (no interpretation was made of the polyphasic pattern



detected in pinewoods according to the low frequencies obtained). Biphasic and monophasic temporal activity patterns were described in wood mice, but these were mainly related to the length of the night and the time of breeding (Wolton 1983, Montgomery and Gurnell 1985). During short summer nights wood mice are breeding in northern Europe (Flowerdew 1985), and monophasic patterns were related to the need of taking profit of all the hours of darkness according to the higher energetic demands of wood mice during the breeding season (Wolton 1983, Corp et al. 1997). Nonetheless, long winter nights in northern Europe (outside the breeding period) produced biphasic patterns. In the Mediterranean area, winter nights are relatively shorter than nights in northern Europe (eg, 13-14 hours versus 14-16 hours in Great Britain, Wolton 1983). However, we detected the same temporal activity pattern that was observed by Wolton (1983) during the long winter nights in Great Britain.

As far as we know, we present the first approach to the study of relative abundance and temporal activity patterns of wood mice by means of remote photography. Our results seemed to indicate that remote photography could be used as an alternative technique to study wood mice temporal activity patterns, but also to estimate its spatial abundance. This method is less labor-intensive, less invasive and less costly than other techniques used (see Cutler and Swann 1999 for discussion on these topics), and seem to provide similar results (Cartew and Slater 1991, Cutler and Swann 1999). Furthermore, this technique can be applied to study the spatial and temporal distribution of wood mice and their mammalian predators (e.g. genets, Torre et al. submitted), providing simultaneous information on the use of sampling stations by small mammals and their predators.

#### ACKNOWLEDGEMENTS

We thank Santi Llacuna for his interest in studying small mammals and carnivores in the Garraf natural park, and Diputació de Barcelona for the financial support. Toni Arrizabalaga provided technical support.

#### REFERENCES

- BARRY, R. E., A. A. FRESSOLA AND J. A. BRUSEO (1989). Determining the time of capture for small mammals. *Journal of Mammalogy*, 70: 660-662.
- BLONDEL, J. AND J. ARONSON (1999). *Biology and Wildlife of the Mediterranean Region*. Oxford University Press, Oxford.
- BRUSEO, J. A. AND R. E. BARRY (1995). Temporal activity of syntopic *Peromyscus* in the Central Appalachians. *Journal of Mammalogy*, 76: 78-82.

- CARLEY C. J., E. D. FLEHARTY AND M. A. MARES (1970). Occurrence and activity of *Reithrodontomys megalotis*, *Microtus ochrogaster*, and *Peromyscus maniculatus* as recorded by a photographic device. *The Southwestern Naturalist*, 15: 209-216.
- CARTHEW, S. M. AND E. SLATER (1991). Monitoring animal activity with automated photography. *Journal of Wildlife Management*, 55: 689-692.
- CORP, N., M. L. GORMAN AND J. R. SPEAKMAN (1997). Ranging behaviour and time budgets of male wood mice *Apodemus sylvaticus* in different habitats and seasons. *Oecologia*, 109: 242-250.
- CUTLER, T. L. AND D. E. SWANN (1999). Using remote photography in wildlife ecology: a review. *Wildlife Society Bulletin*, 27: 571-581.
- Díaz, M., T. Santos and J. L. Tellería (1999). Effects of forest fragmentation on the winter body condition and population parameters of an habitat generalist, the wood mouse *Apodemus sylvaticus*: a test of hypotheses. *Acta Oecologica*, 20: 39-49.
- FLOWERDEW, J. R. (1985). The population dynamics of wood mice and yellow-necked mice. In: J.R. Flowerdew, J. Gurnell and J.H.W. Gipps. (eds). The ecology of woodland rodents. Bank voles and Wood mice. *Symposia of the Zoological Society of London*, 55: 315-338.
- FLOWERDEW, J.R., J. GURNELL AND J.H.W. GIPPS (1985). The Ecology of Woodland Rodents. Bank Voles and Wood Mice. *Symposia of the Zoological Society of London*, 55.
- FONS, R., I. GRABULOSA, M.C. SAINT GIRONS, M.T. GALÁN-PUCHADES AND C. FELIU (1988). Incendie et cicatrization des ecosistemas mediterraneens, dynamique du repeuplement en micromammiferes. *Vie Milieu*, 38, 259-280.
- FONS, R. AND M. C. SAINT-GIRONS (1993). Le cycle sexuel chez le mulot sylvestre, *Apodemus sylvaticus* (L., 1758) en région méditerranéenne. *Zeitschrift für Säugetierkunde*, 58: 38-47.
- FOESMAN, K. R. AND D. E. PEARSON (1999). Activity patterns of American Martens, *Martes americana*, Snowshoe Hares, *Lepus americanus*, and Red Squirrels, *Tamiasciurus hudsonicus*, in westcentral Montana. *Canadian Field Naturalist*, 113: 386-389.
- GARSON, P. J. (1975). Social interactions of Woodmice (*Apodemus sylvaticus*) studied by direct observation in the wild. *Journal of Zoology London*, 177: 496-500.
- Gurnell, J. and J.R. Flowerdew (1990). Live trapping small mammals. A practical guide. *Occ. Publ. Mammal Soc. London*, 3: 1-39.
- HALLE, S. (1988). Avian predation upon a mixed community of common voles (*Microtus arvalis*) and wood mice (*Apodemus sylvaticus*). *Oecologia*, 75: 451-455.
- HICKS, N. G., M. A. MENZEL AND J. LAHERM (1998). Bias in the determination of temporal activity patterns of syntopic *Peromyscus* in the Southern Appalachians. *Journal of Mammalogy*, 79: 1016-1020.
- KIKKAWA, J. (1964). Movement, activity and distribution of the small rodents *Clethrionomys glareolus* and *Apodemus sylvaticus* in woodland. *Journal of Animal Ecology*, 33: 259-299.

- KOTLER, B. P., Y. AYAL AND A. SUBACH (1994). Effects of predatory risk and resource renewal on the timing of foraging activity in a gerbil community. *Oecologia*, 100: 391-396.
- LAMBIN, X. (1988). Social relations in *Apodemus sylvaticus* as revealed by video-observations in the wild. *Journal of Zoology London*, 216: 587-593.
- MARTORELLO, D. A., T. H. EASON AND M. R. PELTON (2001). A sighting technique using cameras to estimate population size of black bears. *Wildlife Society Bulletin*, 29: 560-567.
- MOLTÓ, E., X. ROIJALS, J. A. BURRIEL, J. J. IBÁÑEZ AND X. PONS (2003). Novetats en el Mapa de cobertes del sòl de Catalunya: disponibilitat total a Internet, actualització 2002 I dades per al Garraf. *IV Trobada d'Estudiosos del Garraf, Monografies*, 37: 37-40.
- MONTGOMERY, W. I. AND J. GURNELL (1985). The behaviour of *Apodemus*. In: J. R. Flowerdew, J. Gurnell and J. H. W. Gipps (eds). *The Ecology of Woodland Rodents, Bank Voles and Wood Mice. Symposia of the Zoological Society of London*, 55: 89-115.
- MORENO, S. AND M. B. KUFNER (1988). Seasonal patterns in the Wood Mouse population in Mediterranean scrubland. *Acta Theriologica*, 33: 79-85.
- MORRIS, D. W. AND D. L. DAVIDSON (2000). Optimally foraging mice patch use with habitat differences in fitness. *Ecology*, 81: 2061-2066.
- NAVEH, Z. (1974). Effect of Fire in the Mediterranean Region. Pp. 401-434. In: T. T. Kozłowski and C. E. Ahlgreen (eds). *Fire and Ecosystems*. Academic Press, New York.
- OSTERBERG, D. M. (1962). Activity of small mammals as recorded by a photographic device. *Journal of Mammalogy*, 43: 219-229.
- OTANI, T. (2001). Seed dispersal by Japanese marten *Martes melampus* in the subalpine shrubland of northern Japan. *Ecological Research*, 17: 29-38.
- PEI, K. (1995). Activity rhythm of the spinous country rat (*Niviventer coxingi*) in Taiwan. *Zoology Studies*, 34: 55-58.
- PRODON, R., R. FONS AND F. ATHIAS-BINCHE (1987). The impact of fire on animal communities in mediterranean area. Pp 121-157. In: *The Role of Fire in Ecological Systems*. SPB Academic Publishing, The Hague, .
- RIERA, J. (2003). Evolució del paisatge vegetal del Parc del Garraf en els darrers 100 anys. *IV Trobada d'Estudiosos del Garraf, Monografies*, 37: 59-63.
- SANS-COMA, V. Y J. GOSÁLBEZ (1976). Sobre la reproducció de *Apodemus sylvaticus* L., 1758 en el nordeste ibérico. *Miscel.lània Zoològica*, 3: 227-233.
- TORRE, I. AND M. DÍAZ (2004). Small mammal abundance in Mediterranean post-fire habitats: a role for predators? *Acta Oecologica*, 25: 137-142.
- TORRE, I. , M. DÍAZ, A. PERIS AND L. TENA (submitted). Foraging behaviour of wood mice *Apodemus sylvaticus* as related to presence and activity of genets *Genetta genetta* in Mediterranean forests and shrublands. *Animal Behaviour*.

Galemys 17 (nº especial), 2005

- WOLTON, R. J. (1983). The activity of free-ranging wood mice *Apodemus sylvaticus*. *Journal of Animal Ecology*, 52: 871-794.
- YLÖNEN, H. (1988). Diel activity and demography in an enclosed population of the vole *Clethrionomys glareolus* Schreb. *Annales Zoologici Fennici*, 25: 221-228
- ZAR, J. H. (1996). *Biostatistical analysis*. Prentice Hall, Englewood Cliffs, New Jersey.
- ZUBAID, A. AND M. L. GORMAN (1996). The effect of supplementary food upon the activity patterns of wood mice, *Apodemus sylvaticus*, living on a system of maritime sand-dunes. *Journal of Zoology London*, 238: 759-768.