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USE BY SMALL MAMMALS OF SHORT-ROTATION PLANTATIONS IN RELATION TO THEIR STRUCTURE AND ISOLATION

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ABSTRACT **-** Over the last decades, dramatic changes in agricultural practices have led to important modifications of land-use, as well as landscape structure, and to a general biodiversity loss in agro-ecosystems. During 2008 we investigated the small mammal communities of Short Rotation Forestry (SRF) stands in Northern Italy. We live-trapped small mammals, during summer and autumn, in different types of SRF stands and surrounding habitats and compared capture rates. We evaluated the influence on small mammals abundance of the distance between the stands and other habitats offering woody or bushy cover. Our results showed that SRF plantations are widely exploited by small mammals, especially in autumn and that capture rate is the highest in "double-row" stands. The distance from woods or other arboriculture stands was negatively correlated to small mammals abundance. We conclude that SRF plantations can be considered a suitable habitat for small mammals and may work as a "corridor habitat" between fragmented patches of suitable habitats.

Key words: poplar plantations, small mammals abundance, stand structure, connectivity

RIASSUNTO **-** ***Uso degli impianti a turno breve da parte dei micrommamiferi, in relazione alla loro struttura e isolamento***. Negli ultimi decenni profondi cambiamenti nelle pratiche agricole hanno causato modifiche nella tipologia di uso dei terreni, così come nella struttura del paesaggio, che hanno portato a una generale perdita di biodiversità negli agroecosistemi. Nel corso del 2008 abbiamo studiato le comunità di micromammiferi nelle piantagioni di pioppo per la produzione di biomassa (SRF) nel Nord Italia. Con l'uso di *live-traps* abbiamo effettuato due sessioni di cattura, una estiva e una autunnale, nei diversi tipi di impianto delle SRF e negli ambienti circostanti, per comparare le frequenze di cattura. Abbiamo quindi analizzato l'influenza che la distanza tra i diversi ambienti con copertura arborea ha sull'abbondanza dei micromammiferi. Dal nostro studio è emerso che le SRF sono largamente sfruttate dai micromammiferi, soprattutto in autunno e che il successo di cattura è massimo negli impianti a file binate. L'abbondanza dei micromammiferi è risultata inversamente correlata alla distanza dagli ambienti che offrono copertura, come boschi o altri impianti di arboricoltura. I risultati hanno mostrato che le SRF possono considerarsi un ambiente idoneo per i micromammiferi, ed esse potrebbero funzionare da habitat di collegamento tra i frammenti di altri habitat utilizzati dai micromammiferi.

Key words: piantagioni a turno breve, micromammiferi, abbondanza, struttura delle piantagioni, connettività

INTRODUCTION

The reduction of habitat quality, coupled with the increase in homogeneity of agricultural landscapes, are probably the main causes of biodiversity loss on farmland (Benton *et al.*, 2003; Donald *et al.*, 2006). These changes have reduced the availability of resources such as food, shelter and breeding sites for birds and mammals both in arable and pastoral lands (Vickery *et al.*, 2001; Firbank, 2005). The size and distance between suitable habitat patches play an important role in the survival of animal populations; the connectivity between these patches within the landscape matrix has therefore become a key issue in the conservation of biodiversity (Hanski, 1999).

Small mammals are common inhabitants of agricultural landscapes where they play an important role as prey for both terrestrial and avian predators (Prigioni, 1991; Cecere and Vicini, 2000). They are often confined to field margins and non-cropped areas, where they can find food and cover from predators (Yahner, 1983; Fitzgibbon, 1997; Ouin *et al.*, 2000) and move between suitable patches (Bennett, 1990; Merriam and Lanoue, 1990; Fitzgibbon, 1997; Klaa *et al.*, 2005; Gelling *et al.*, 2007). It is well documented how several species, not only mammals, use linear habitats like hedgerows and road verges to move through arable lands (Petit and Burel, 1998; Haddad and Baum, 1999; Hinsley and Bellamy, 2000; Aviron *et al.*, 2005).

In recent years, Short-Rotation Forestry (SRF) for producing biomass for energy has become widespread across Europe. This alternative use of arable land could offer an opportunity for the energetic self-supply of rural areas and diversification of the agricultural production (Gruenewald *et al.*, 2006), which, in turn, could lead to an improving of landscape heterogeneity. These stands differ from traditional poplar plantations for their higher density of plants, shorter cutting regimes and lower anthropic interference.

Agriculture is the dominant land-use in Italy (Falcucci *et al.*, 2007), particularly in the plain of the River Po (Northern Italy), but SRF is also becoming more and more common in the wider Italian countryside. Few studies have been carried out to assess the importance of these plantations for small mammals (Christian *et al.*, 1997; Christian *et al.*, 1998; Moser *et al.*, 2002) and none to evaluate their role as corridors. The aim of our research was to assess the potential importance of SRF for small mammals by determining which species utilize poplar plantations and analysing the relation between their distance from other suitable habitats and the abundance of small mammals.

STUDY AREA

The study was carried out in summer and autumn 2008 at four sites, located in the River Po plain (Province of Pavia, Northern Italy). All sites were located in protected areas and selected to include areas with different amounts of woods, crops and SRF stands (Tab. 1). Two areas were located in the irrigated plain north of the River Po and two in the dry crop plain to the south of the river. The main crops were cereals (winter wheat, barley, maize, and rice), legumes (soybean and peas), and hay fields

Table 1 - Characteristics (% land use) and locations of study sites.

Study sites	Ha	SRF	Reforestations	Poplar plantations	Woods	Edge vegetation	Crops	Location
Site 1	479	1.28	0.77	0.67	5.11	4.83	75.49	45° 2' 29'' N 8° 56' 56'' E
Site 2	229	26.79	3.57	-	6.87	4.29	44.09	45° 3' 43'' N 9° 1' 2'' E
Site 3	816	6.43	0.90	5.46	1.16	3.51	56.42	45° 12' 42'' N 9° 18' 33'' E
Site 4	790	8.14	4.97	1.67	35.04	3.06	35.11	45° 12' 29'' N 9° 0' 50'' E

(clover, alfalfa, and *Lolium italicum*). Woods mainly consisted of *Quercus* sp., *Salix* sp. and *Ulmus minor*. Spontaneous vegetation was also present along channel banks, field edges, riversides, and fallow fields. Short rotation forestry stands varied in number from 1 to 36 and they were of the type "double row" at site 1, both "single row" and "double row" at sites 2 and 3, and "single row" at site 4. At sites 2, 3 and 4 some plantations had been cut just before the beginning of the study, so were included in a separated category named "cut". All the investigated plantations consisted of poplar clones. In the study sites other types of arboriculture were present, in particular reforestations, with a density of up to 1200 plants per ha of several autochthonous species and with a rotation of 20 years. Traditional poplar plantations, with a density of 250 plants per ha and a 10-year rotation were also present.

The climate of the study areas is subcontinental; the mean annual temperature was 13.9 °C with a maximum of 25.2 °C in July and a minimum of 2.2 °C in January. Annual precipitation averaged 700 mm, most of which in spring and autumn. The morphology of the study areas is flat, with sandy and sandy-loam soils.

METHODS

1. Small mammal sampling

We trapped small mammals using five different types of live-traps to maximize the chances to catch all present species. The traps used were Sherman, Ugglan, multicatch, wire cage, and tube traps. At sites 1, 2 and 4 only SRF stands were sampled, while at site 3 other habitat types including woods, crops, traditional poplar plantations, reforestations and fallow fields were also sampled.

Two trap lines were located inside each field, one at the margin, the other in the centre of the field. Ten traps, each 10 m apart, were located in each transect. A total of 540 traps were used (site 1: 20 traps; site 2: 120 traps; site 3: 320 traps; site 4: 80 traps). Traps were left in place for 4 consecutive days and checked daily. The traps were not baited. Each individual captured was identified to species and then released at capture site. There were two trapping sessions, one in summer (June-July) and one in autumn (November-December).

2. Data analysis

We checked for significant differences of catch frequency between seasons and among habitats by the Likelihood ratio (exact test with permutation); then carried out correlation analyses (Spearman rho) to evaluate the strength and the direction of the relationship between the number of individuals caught and some habitat variables descriptive of the isolation of the sampled SRF stands and of the characteristics of the study site (Tab. 2). All these analyses were performed considering both all the species together and the most abundant species alone. Correlations were tested considering both the number of individuals caught per sampled SRF stand and the number of individuals caught per transect. Finally we calculated a relative index of the abundance of small mammals per habitat.

RESULTS

We captured 144 individuals (54 in summer, of which 26 in SRF stands; 90 in autumn, of which 67 in SRF stands) of four rodent and one soricomorph species during 64 trap nights (32 in both summer and autumn). Four of these species were caught in SRF fields. The dominant species was the wood mouse (*Apodemus sylvaticus*), followed by Savi's pine vole (*Microtus savii*) and the bank vole (*Clethrionomys glareolus*) (Tab. 3).

Considering the data of the four sites together, trapping success was significantly higher in autumn than in summer (χ^2= 13.50, d.f.=1, P<0.0001), even when considering only the wood mouse (χ^2= 21.92, d.f.=1, P<0.0001). Significant differences emerged between the different types of SRF stands in both seasons (summer: χ^2=7.03, d.f.=2, P=0.029; autumn: χ^2=15.92, d.f.=2, P=0.002), even for the wood mouse alone (summer: χ^2=7.56, d.f.=2, P=0.022; autumn: χ^2=12.41, d.f.=2, P=0.002); in both seasons "double row" SRF stands showed the highest trapping success. There was no significant difference between the edge and the central part of the SRF stands (summer: χ^2=1.29, d.f.=1, P=0.165; autumn: χ^2=0.50, d.f.=1, P=0.273).

At site 3 we found a significant difference in the catch frequency of small mammals among different habitats in both seasons (summer: χ^2=21.63, d.f.=7, P=0.003; autumn: χ^2=21.97, d.f.=7 P=0.003). In summer woods were the most used habitats, while in autumn "double row" SRF stands were the most exploited habitats . Considering the wood mouse alone the difference was significant only in autumn(χ^2=15.68,

Table 2 - Habitat variables measured for each study site.

Variable	Description
SRF Distance	Distance between the sampled stand and the closest one
Reforestation Distance	Distance between the sampled SRF stand and the closest reforestation stand
Poplar Distance	Distance between the sampled SRF stand and the closest traditional poplar plantation
Wood Distance	Distance between the sampled SRF stand and the closest wood patch
% Wood	Percentage of woodland in each study site
% SRF	Percentage of SRF in each study site
% Reforestations	Percentage of reforestations in each study site
% Poplar	Percentage of traditional poplar plantations in each study site
% Crops	Percentage of crops in each study site

Table 3 - Number of individuals per species caught in SRF stands in summer and autumn trapping sessions (s.r = single row; d.r = double row).

	SUMMER			AUTUMN		
	cut SRF	s.r SRF	d.r SRF	cut SRF	s.r SRF	d.r SRF
Apodemus sylvaticus	8	5	7	14	21	22
Microtus savii	0	2	1	1	0	5
Clethrionomys glareolus	0	2	0	0	1	0
Crocidura suaveolens	1	0	0	0	3	0

d.f.=7, P=0.029), when SRF stands and reforestations had a higher capture rate than the other habitats. A negative relationship resulted between the number of small mammals caught in SRF stands and the distance to the nearest SRF stand, particularly in autumn (rho= -0.61, N=17, P=0.007), including when considering the wood mouse alone (rho= -0.73, N=17, P=0.001). The number of wood mice caught in "single row" plantations in autumn was positively correlated with the percentage of woodland in each area and negatively correlate with the percentage of crops (rho=0.89, N=6, P=0.02 and rho= -0.89, N=6, P=0.02, respectively). The number of wood mice caught in "double row" stands was negatively correlated with the distance to the nearest woodland patch (rho= -0.70, N=10, P=0.025), and positively with the percentage of woods (rho=0.78, N=10, P=0.008) in the study sites.

In summer, the number of small mammals caught per transect in "cut" SRF stands was positively correlated with the distance to the nearest woodland patch (rho= 0.81, N=12, P=0.002) and with the percentage of crops (rho= -0.66, N=12, P=0.018), and negatively with the percentage of woods (rho= -0.83, N=12 P=0.018), reforestations (rho= -0.83, N=12, P=0.001) and SRF (rho= -0.66, N=12, P=0.001) in the area. In autumn we found an opposite trend, with a negative correlation with the distance to the nearest woods (rho= -0.62, N=12, P= 0.031) and a positive correlation with the percentage of SRF stands (rho = 0.61, N=12, P= 0.037) and reforestations (rho = 0.61, N=12, P= 0.038).

Otherwise for the "double row" stands we found negative correlations between the number of small mammals caught per transect and the distance to the nearest wood patch (rho= -0.92, N=8, P=0.001), SRF stand (rho= -0.76, N=8, P=0.029) and crops percentage (rho= -0.94, N=8, P=0.001), instead there was a positive relationship with the presence of woodland, reforestation and SRF (rho= 0.94, N=8, P=0.001) in the area. There was no evidence that the percentage or distance from traditional poplar plantations could influence the abundance of small mammals.

The abundance index showed that "double row" stands were the most used plantations, considering both all habitat types and SRF types alone; in particular, the abundance of small mammals in these stands showed a peak in autumn (Figures 1 and 2).

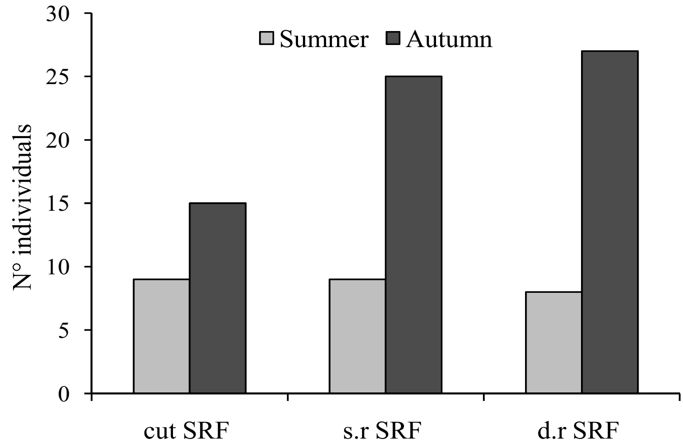

Figure 1 - Relative abundance of small mammals in relation to SRF types (pooled study sites; s.r = single row, d.r = double row).

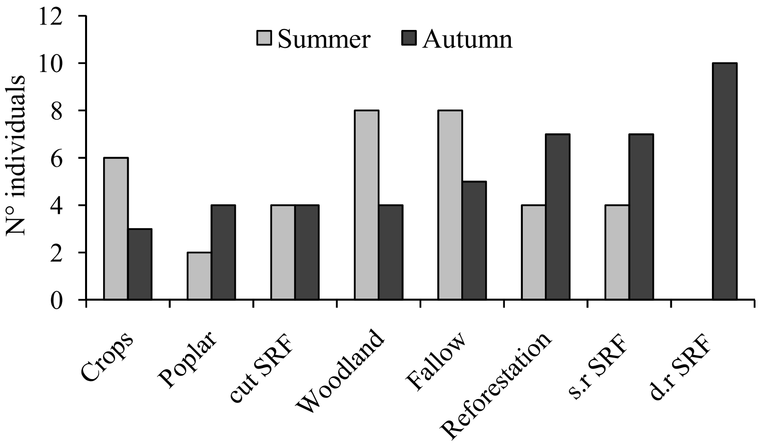

Figure 2 - Relative abundance of small mammals in relation to land use classes in study site 3 (s.r = single row, d.r = double row).

DISCUSSION

The distribution of small mammals in agricultural landscapes is strongly influenced by food diversity and availability (Butet *et al.*, 2006). Recent investigations have shown that agricultural communities of small mammals tend to include mainly generalist species; more specialized species tend to be found only in less disturbed habitats (Millán de la Peña *et al.*, 2003).

As expected, the dominant species at our study sites was the wood mouse, an opportunistic species able to move among different habitats, depending on the availability of food and shelter (Zhang and Usher, 1991; Ouin *et al*., 2000).

The bank vole is typically a woodland and rather sedentary species (Bergstedt, 1965; 1966), which may also live in agricultural environments (Fitzgibbon, 1997; Butet *et al*., 2006). The selection of this species for SRF plantations may be linked to its structural features, quite similar to that of a natural wood because of his high plant density, rather than to a preference for cover *per se*, as no individual was found in other types of arboriculture (traditional poplar plantations and reforestations). Moreover bank voles were caught in both seasons, suggesting a continuous habitat exploitation. The presence in SRF stands of the lesser white-toothed shrew is relevant, primarily because it is considered a priority species for biodiversity conservation, and also because Soricomorphs are very sensitive to anthropogenic environmental changes; consequently, its presence in SRF stands testifies that these plantations provide little disturbed habitats.

The higher number of small mammals caught in autumn reflects the biological cycle of rodents, which show the lowest density in summer, after the breeding season and a peak in autumn (Kikkawa, 1964; Montgomery, 1989).

In autumn, SRF plantations may provide food and shelter from predators, when, in comparison, out with the SRF, crops are mostly ploughed and crossing such areas makes the small mammals more susceptible to predation. SRF stands seem to be preferred to woodland, if this is highly fragmented as at site 3. In these terms, besides offering suitable corridors, SRF could also represent a compensatory covered habitat in overworked agricultural lands.

The preference for "double-row" stands is probably linked to the higher degree of tree cover which these plantations provide when compared with "single row" ones. However, this preference may also depend on microhabitat parameters, which have not been analysed in this study.

Another key factor in determining the presence of small mammals was the closeness of other habitats offering cover (arboriculture stands and natural woods). This result suggests that connectivity between residual wooded patches, whether natural or not, enhances the dispersion of both Rodents and Soricomorphs, and may play a main role also for other mammals, such as Lagomorphs.

SRF stands were also exploited in the post-cut period, although they are open habitats where small mammals are more easily subject to predation. This preference for "cut" SRF cannot be justified by the search for shelter but, maybe, by the selection for habitats that are pesticides-free, as reported by Tew *et al*. (1992) for wood mice.

The study showed that several small mammals species exploit Short Rotation plantations, and that they prefer this habitat to crops, especially during autumn, when they concentrate in habitat which offer tree and ground cover. SRF plantations *per se* may act as compensatory covered habitats in ecosystems with a reduced presence of natural woods, such as those of the

River Po plain. However the abundance of small mammals in SRF stands strictly depends on their proximity to other habitats offering suitable cover. From this perspective, creating a continuous system of covered habitat, with arboriculture stands acting as *stepping stones* between wood patches, could allow small mammals to move freely through the cultivated matrix and favour the conservation of biodiversity in agricultural landscapes.

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REFERENCES

Aviron S., Burel F., Baudry J. and Scherman N. 2005. Carabid assemblages in agricultural landscapes: impacts of habitat features, landscape context at different spatial scales and farming intensity. *Agr. Ecosyst. Environ*., 108: 205–217.

Bennett A.F. 1990. Habitat corridors and the conservation of small mammals in a fragmented forest environment. *Landscape Ecol*., 4 (2/3):109-122.

Benton T.G., Vickery J.A. and Wilson J.D. 2003. Farmland biodiversity: is habitat heterogeneity the key? *Trends Ecol. Evol*., 18 (4): 182-188.

Bergstedt B. 1965. Distribution, reproduction, growth and dynamics of the rodent species *Clethrionomys glareolus* (Schreber), *Apodemus flavicollis* (Melchior) and *Apodemus sylvaticus* (Linné) in Southern Sweden. *Oikos*, 16 (1/2): 132-160.

Bergstedt B. 1966. Home ranges and movements of the rodent species *Clethrionomys glareolus* (Schreber), *Apodemus flavicollis* (Melchior) and *Apodemus sylvaticus* (Linné) in Southern Sweden. *Oikos*, 17 (2): 150-157.

Butet A., Pallat G. and Delettre Y. 2006. Seasonal changes in small mammal assemblages from field boundaries in an agricultural landscape of western France. *Agr. Ecosyst. Environ*., 113: 364–369.

Cecere F. and Vicini G. 2000. Micrommals in the diet of the long eared owl *(Asio otus)* at the W.W.F.'s oasi. San Giuliano (Matera, South Italy). *Hystrix It. J. Mamm*., 11(2): 47-53.

Christian D.P., Collins P.T., Hanowsky J.M. and Niemi G.J. 1997. Bird and small mammals use of short-rotation hybrid poplar plantations. J. *Wildl. Manage*., 61(1): 171-182.

Christian D.P., Hoffman W., Hanowsky J.M., Niemi G.J. and Beyea J. 1998. Bird and mammal diversity on woody biomass plantations in North America. *Biomass Bioen*., 124 (4): 395-402.

Donald P.F., Sanderson F.J., Burfield I.J. and van Bommel F.P.J. 2006. Further evidence of continent-wide impacts of agricultural intensification on European farmland birds, 1990–2000. *Agr. Ecosyst. Environ*., 116: 189–196.

Falcucci A., Maiorano L. and Boitani L. 2007. Changes in land-use/land-cover patterns in Italy and their implications for biodiversity conservation. *Landscape Ecol*., 22: 617–631.

Firbank L.G. 2005. Striking a new balance between agricultural production and biodiversity. *Ann. Appl. Biol*., 146: 163–175.

Fitzgibbon C.D. 1997. Small mammals in farm woodlands: the effects of habitat, isolation and surrounding land-use patterns. *J. Appl. Ecol*., 34 (2): 530-539.

Gelling M., Macdonald D.W., and Mathews F. 2007. Are hedgerows the route to increased farmland small mammal density? Use of hedgerows in British pastoral habitats. *Landscape Ecol*., 22: 1019-1032.

Gruenewald H, Brandt B.K.V., Schneider B.U., Bens O., Kendzia G. and Hüttl R.F. 2007. Agroforestry systems for the production of woody biomass for energy transformation purposes. *Ecol. Eng*., 29: 319–328.

Hansky I. 1999. Habitat connectivity, habitat continuity, and metapopulations in dynamic landscapes. *Oikos*, 87: 209-219.

Haddad N.M. and Baum K.A. 1999. An experimental test of corridor effects on butterfly densities. *Ecol. Appl*., 9 (2): 623-633.

Hinsley S.A. and Bellamy P.E. 2000. The influence of hedge structure, management and landscape context on the value of hedgerows to birds: A review. J. *Environ. Manage*., 60, 33–49 .

Kikkawa J. 1964. Activity and distribution of the small rodents *Clethrionomys glareolus* and *Apodemus sylvaticus* in Woodland. *J. Anim. Ecol*., 33 (2): 259-299.

Klaa K., Mill P.J. and Incoll L.D. 2005. Distribution of small mammals in a silvoarable agroforestry system in Northern England. *Agroforest. Syst*., 63: 101-110.

Merriam G. and Lanoue A. 1990. Corridor use by small mammals: field measurement for three experimental types of *Peromyscus leucopus*. *Landscape Ecol*., 4 (2/3): 123-131.

Millán De La Peña N., Butet A., Delettre Y., Paillat G., Morant P. and Burel F. 2003. Response of the small mammal community to changes in western French agricultural landscapes. *Landscape Ecol*., 18: 265–278.

Montgomery W.I. 1989. Population regulation in the wood mouse, *Apodemus sylvaticus*. I. Density dependence in the annual cycle of abundance. *J. Anim. Ecol*., 58 (2): 465-475.

Moser B.W., Pipas M.J., Witmer G.W. and Emgeman R.M. 2002. Small mammals use of hybrid polar plantations relative to stand age. *Northwest Science*, 76 (2): 158-165.

Ouin A., Paillat G., Butet A. and Burel F. 2000. Spatial dynamics of wood mouse (*Apodemus sylvaticus*) in an agricultural landscape under intensive use in the Mont Saint Michel Bay (France). *Agr. Ecosyst. Environ*., 78: 159-165.

Petit S. and Burel F. 1998. Effects of landscape dynamics on the metapopulation of a ground beetle (Coleoptera, Carabidae) in a hedgerow network. *Agr. Ecosyst. Environ*., 69: 243-252.

Prigioni C. 1991. Lo studio della dieta della volpe *Vulpes vulpes*. *Hystrix*, 3: 51-62.

Tew T.E, Macdonald D.W. and Rands M.R.W. 1992. Herbicide application affects microhabitat use by arable wood mice (*Apodemus sylvaticus*). *J. Appl. Ecol*., 29 (2): 532-539.

Vickery J.A., Tallowin J.R., Feber R.E., Asteraki E.J., Atkinson P.W., Fuller R.J. and Brown V.K. 2001. The management of lowland neutral grasslands in Britain: effects of agricultural practices on birds and their food resources. *J. Appl. Ecol*., 38: 647-664.

Yahner R.H. 1983. Small mammals in farmstead shelterbelts: habitat correlate of seasonal abundance and community structure. *J. Wildl. Manage*., 47 (1): 74-84.

Zhang Z. and Usher M. B. 1991. Dispersal of wood mice and bank voles in an agricultural landscape. *Acta Theriol*., 36: 239-245.