POLISH JOURNAL OF ECOLOGY (Pol. J. Ecol.)	56	4	673–682	2008

Regular research paper

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THE POTENTIAL ROLE OF NESTS OF BLACK-BILLED MAGPIE *PICA PICA* L. IN ACCUMULATION AND DISPERSAL OF SEEDS IN AGRICULTURAL LANDSCAPE

ABSTRACT: The study aimed to describe the seed pool accumulated in the nest material of Magpie *Pica pica*, and to determine the importance of this mechanism of seed dispersal for such ecological processes as colonization of new habitats and expansion of alien plants. The seedling germination and seed extraction methods were used to determine seed abundance in the soil layer, the inner layer, and in the lining of 9 nests collected in three types of agricultural landscape: the first with domination of arable fields; the second with similar shares of arable fields and other landscape elements such as meadows of different types, shrubs, tree clumps and rushes; and the third with domination of lowland hay meadows. In all the nests, considerable numbers of diaspores were found (from 26 to 371 seeds per nest, belonging to more than 80 taxa). The main plant groups found in the nests are species connected with field roads, weeds and ruderal species, but also meadow and brushwood species were found there. The soil was gathered by birds from habitats with low vegetation cover and large areas of bare soil. Although the structure of seed pool of nests suggests that soil was mainly collected in the close vicinity of the nests' future location, this mechanism of seed dispersal can probably be involved in long distance dispersal. Seeds of two rare kenophytes: *Erucastrum gallicum* (Willd.) O. E. Schulz and *Diplotaxis tenuifolia* (L.) DC were found in the material of nests localized more than 100 m away from their closest populations. It can be assumed that this mechanism of seed dispersal can play a potential role in the expansion of alien plants and colonisation of new habitats.

KEY WORDS: agricultural landscape, fragmented populations, nest, *Pica pica*, seed bank, seed dispersal

1. INTRODUCTION

According to Eriksson (1996), three models of plant populations can be observed. Remnant populations, built up by long-lived plants with clonal propagation, or plants with extensive seed bank, can persist over periods long enough to bridge unfavourable phases. Metapopulations, characteristic for short-lived or highly specialised plants with good dispersal, are the system of local populations and non-occupied, but potentially suitable sites. The special case of metapopulations are source-sink populations comprising persistent refuge population and ephemeral ones, maintained by dispersal. Sink populations would disappear without continued immigration from productive source habitats (Pulliam 1988). In fragmented agriculture landscape metapopulation composed of interconnected patches and fluxes among them is suggested as a good and understandable demographic unit (Merriam 1988). Local extinctions are very common in fragmented populations and recolonisation is the crucial process for their regional survival. The probability of recolonisation depends on dispersal ability of organisms, spatial relationships among landscape elements and temporal changes in the landscape structure (Fahring and Merriam 1992).

Seed dispersal links the end of reproductive cycle with the establishment of a new generation (Wang and Smith 2002). The main benefits of seed dispersal, according to *"Escape, Colonisation and Direct Dispersal Hypotheses"* are the escape from density-dependent mortality in the close vicinity of parent plant; the chance of occupying favourable sites which are unpredictable in space and time, and the direct dispersal to safe microsites (Howe and Smallwood 1982, Howe and Miriti 2000). Many key aspects of biology of plants (spread of invasive species, metapopulation dynamics, gene flow among populations, distribution of genetic variation, diversity and dynamics of plant communities) may be influenced by long distance seed dispersal events (LDD – *long distance dispersal*). They are very rare and very difficult to study because of their low frequency (Ouborg *et al.* 1999, Wang and Smith 2002). LDD can be defined in two ways: relative or absolute. Seed density declines leptocurtically with the distance from the parent plant, with extended "*tail*" of long-distance dispersal – as long distance the upper 1% of seed dispersal distances is treated (Cain *et al.* 2000, Nathan and Muller-Landau 2000). Sometimes dispersal event is considered to be "long distance" when it extends over 100 m (Cain *et al.* 2000). In LDD several dispersal agents can be involved. Vertebrate and wind dispersal (mainly in updrafts and storms) seem to be very effective (Cain *et al.* 2000). In the literature we can find a lot of examples of epi- and endozoochory, with different groups of animals involved (e.g. lizards, birds, hares, sheep) and some of them can be treated as long distance dispersal (Barnea *et al.* 1992, Debussche and Isenmann 1994, Izhaki and Ne'eman 1997, Nogales *et al.* 1998, Willerding and Poschold 2002).

LDD is often caused by the so-called nonstandard means of dispersal, when factors which cannot be linked with morphology of seeds are involved. One of them is the transporting of seeds with nest material by birds (Higgins *et al.* 2003). The aim of the present study was to evaluate the role of nest material collected by Black-billed Magpie *Pica pica* in seed accumulation and dispersal. Nests of Magpies contain a large amount of soil which can potentially contain some amount of seeds.

This study is the attempt to answer the following questions:

1. What is the size and structure of the bank of diaspores gathered in the nests of *Pica pica*, a bird connected with agricultural landscape?
2. What elements of agricultural landscape are the main source of the nest material?
3. Can the nests of Black-billed Magpie play any role in the long distance dispersal of seeds?

The answer to the second question will help us explain some aspects of the bird behaviour and will indicate ecological groups of plants with higher probability of presence of this type of dispersal mechanism.

2. STUDY AREA, MATERIAL AND METHODS

The study was carried out in the hilly region (close vicinity of Chełm city, Eastern Poland). This area is characteristic of the extensive type of farming system, with a small area of arable fields, a relatively dense network of linear landscape elements such as field roads, balks or hedgerows, and the frequent abundance of clumps trees and shrubs. Wide meadows with clumps of trees or shrubs and networks of ditches are also typical landscape elements here.

Black-billed Magpies build their nests between late January and early March (Birkhead 1991, Czarnecka, Kitowski unpublished data). The nest sites in a farmland landscape are usually hedgerows, rows of trees and clumps of trees and shrubs (Górska and Górski 1997). Nests have a multilayered structure: the external layer of stick surrounds the clay or mud layer, the inner twig or root layer, and the inner lining. The

Table 1. Spearman rank correlations of percentage share of landscape elements in the vicinity of nests with axes of PCA diagram (only statistically significant correlations are listed).

Landscape element	Correlation with axis 1	Correlation with axis 2
Arable fields and bulks	–0.96; *P* <0.0001	0.41; NS
Meadows	0.99; *P* <0.0001	–0.61; NS
Hedgerows	0.78; *P* <0.05	–0.77; *P* <0.05

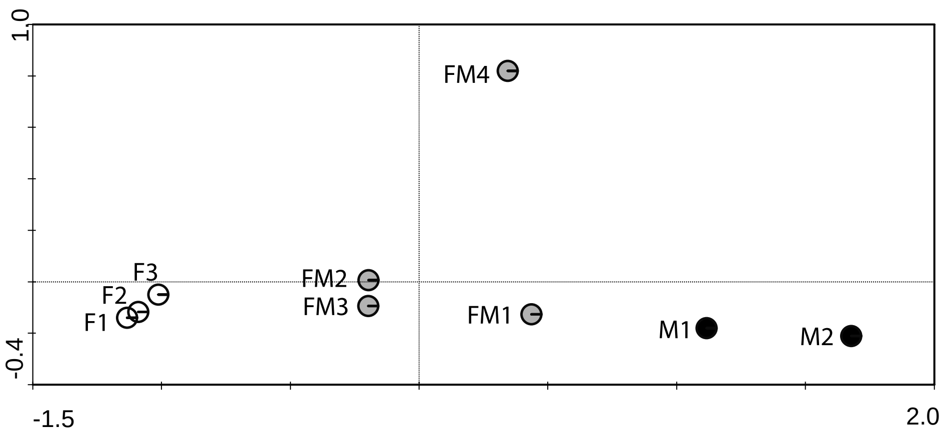

Fig. 1. Principal components analysis (PCA) ordination of surroundings of analysed nests of *Pica pica*. F1-F3 – nests surrounded mainly by arable fields; FM1-FM4 – nests surrounded by fields and meadows; M1-M2 – nests surrounded mainly by meadows. Analysis was based upon the percentage share of landscape elements within a 250 m radius of the nests (Eigenvalues: axis 1 – 0.886, axis 2 – 0.088; cumulative percentage variance: axis 1 – 88.6, axis 2 – 97.4).

whole nest can weight up to a few kilograms and it is usually used only once (Birkhead 1991). The mean territory size of a pair of European magpies is approximately 5–7 ha large (Birkhead 1991). In Poland (data from NW Poland) the mean breading density of rural populations varies between 0.3 in the open farmland landscape and 21.2 pairs km^{-2} in villages (Górski 1997). Nest material is usually collected within a territory but birds may fly beyond their territory boundary to find soil material (Birkhead 1991).

Nine nests (without the external stick layer) of Magpie were collected after the breeding season (late autumn 2006 or early spring 2007) in three types of the surrounding landscape: the first one with the domination of arable fields (F code), the second one with a similar share of arable fields and other landscape elements such as meadows of different types, shrubs, tree clumps and rushes (FM code), and the last one with the domination of lowland hay meadows (M code, Fig. 1, Table 1). All the nest layers collected for the study were subsequently separated, described and weighted. The soil (clay or mud) layer and inner layers (twigs and soft lining together) were put into plastic boxes and kept moist in cold frames for six months. All emerging seedlings were counted and identified. After six months the volume of soil was reduced by washing on the sieve (diameter of 0.25 mm). Then, under the magnification of 10×, all the seeds left ungerminated were picked out and identified.

In July and August all landscape elements (arable fields and bulks, roads and roadsides, clumps of trees and shrubs, hedgerows, abandoned farms, embankments and surface working of cement plant, meadows and rushes) were identified within a 250 m radius of the nests. Their area and percentage share were estimated. This area was bigger than mean territory size of a pair of Magpies, but there were no specific information about the area penetrated by birds during the collection of soil material. All species with their abundance were recorded in representative landscape elements around each nest. The following abundance scale for vegetation data was used: 0.5 – sporadic species, 1 – cover less than 10%, 2 – 11-20%, 3 – 21-30%, …, 10 – 90-100%.

To analyse seed bank data and vegetation data the Canoco 4.5 software was used. Seed bank data were standardised to make them comparable with the vegetation ones in the following way: 0.5 – sporadic species, with only one seed recorded or with the share less than 1%, 1 – share up to 10%, 2 – share between 10 and 20%, …, 10 share between 90 and 100%. Principal components analysis (PCA) was conducted to estimate similarity among the surrounding of nests and detrended correspondence analyses (DCA) was used to analyse relations between seed pool of nests and vegetation (ter Braak and Šmilauer 2002). Sperman rank correlation was calculated with help of Statistica.Pl software.

The percent similarity index (PS), was calculated according to Beatty (1991):

$$PS = 1 - 0.5 \times \left[\sum_{i=1}^{n} \left| p_{ia} - p_{ib} \right| \right]$$

p_{ia} – species „i” relative importance in plant community,

p_{ib} – species „i” relative importance in seed pool of nest.

3. RESULTS

3.1. Seed pool of nests

Nests of Magpies contained quite big and various amount of soil (291 g in the case of exceptionally small nest FM3 up to 2763 g in the case of FM4 nest). Inner twig or root layer and the inner lining were much lighter and they were built mainly of tiny roots, rhizomes of *Elymus repens* and tiny sticks of *Betula* sp. (Table 2). Soil layer was the place of accumulation of large amounts of plant diaspores – the analysed nests contained from 26 up to 371 seeds (Table 3, Appendix). Fewer seedlings germinated from the inner twig layer and in the lining (4 in the case of F2; 1 in F3; 2 in FM1; 5 in M1 and 3 in M2; species germinated from inner layers of nests were marked in Appendix). Their low number suggests that the direct seed shedding into the nests is of little importance: the vast majority of diaspores was transported into the nests together with the soil. Moreover, out of the F1 nest's lining, which consisted of rhizomes of *Elymus repens*, there grew three ramets of this species. The ecological structure of nest seed pool in the case of nests surrounded by fields (F group) and fields and meadows (FM group) was similar. The majority of species represent the following ecological groups: species connected with "green" field roads (mainly *Lolium perenne* and *Plantago major*), ruderal species and weeds. Meadow species and bushes (*Sambucus nigra* and *Cornus sanguinea*) were the most numerous groups of species in the case of nests surrounded by meadows (M group; Appendix).

Table 2. Characteristics of nests of *Pica pica* and their surrounding habitats.

Type of surrounding habitats	Code of nest	Dry weight (g)		Material of inner layers
		Soil	Inner layers	
Mainly arable fields	F1	1541	54	rhizomes of *Elymus repens*
	F2	926	232	leaves, rhizomes of *Elymus repens*, tiny roots
	F3	1870	243	rhizomes of *Elymus repens*, tiny roots
Arable fields and meadows	FM1	1283	175	tiny roots, tiny sticks of *Betula* sp.
	FM2	2014	421	tiny roots, tiny sticks of *Betula* sp.
	FM3	291	55	tiny roots
	FM4	2763	202	tiny sticks, tiny roots
Mainly meadows	M1	1531	20	tiny roots
	M2	1740	48	tiny roots, rhizomes of *Elymus repens*

Table 3. Characteristics of the seed pool of soil layer of nests of *Pica pica.*

	Fields			Fields and meadows				Meadows	
	F1	F2	F3	FM1	FM2	FM3	FM4	M1	M2
Number of seeds per nest	371	280	62	131	171	26	102	49	243
Number of seeds per 1000 g of soil	264	333	38	119	95	127	49	36	153
Number of taxa	15	40	22	27	21	4	29	19	19

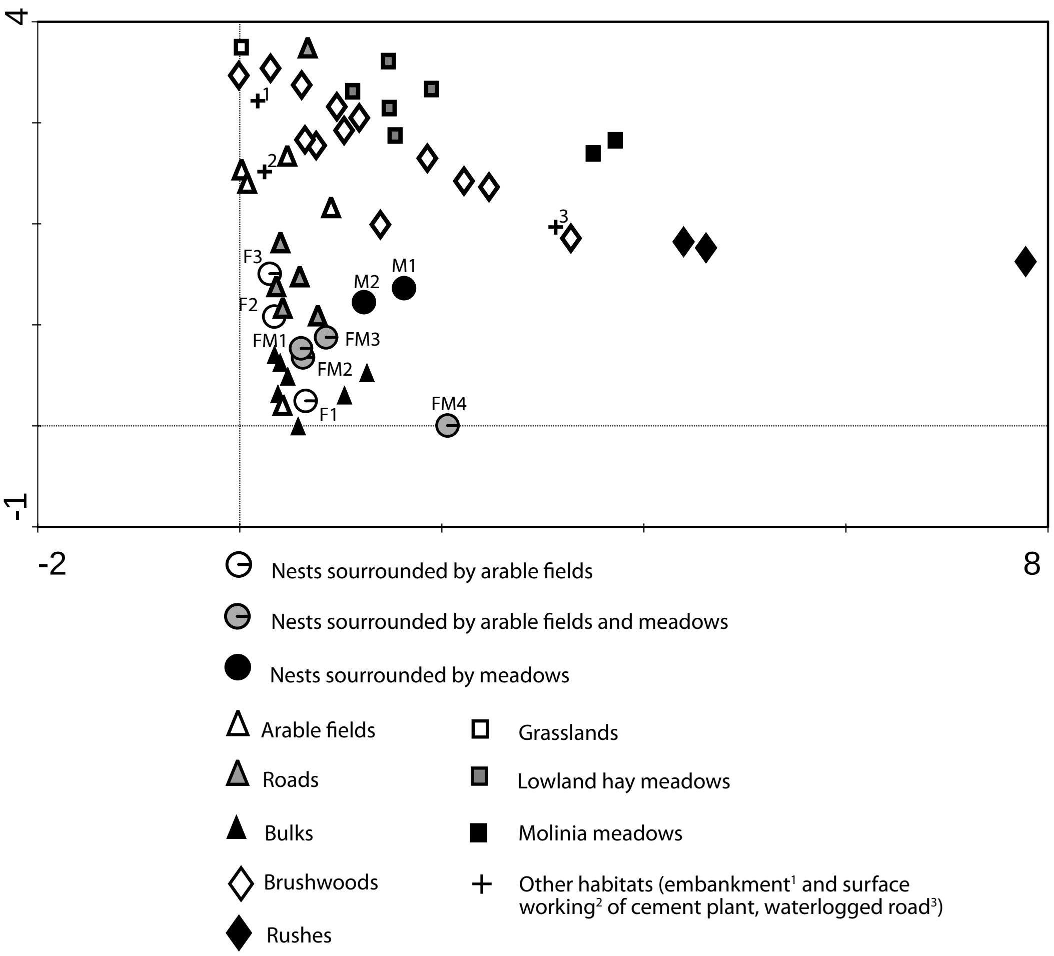

Fig. 2. Detrended correspondence analysis (DCA) ordination of vegetation and nest seed pool structure (Eigenvalues: axis 1 – 0.884, axis 2 – 0.501; cumulative percentage variance: axis 1 – 8.6, axis 2 – 13.6).

3.2. Seed pool structure *versus* surrounding vegetation

The soil forming nest material was picked up in places easily accessible to birds, mainly those characteristic of a low vegetation cover and a large area of bare soil. Sperman rank correlation between vegetation cover and value of percent similarity index (seed pool in nests *versus* vegetation structure) was –0.6007 (P <0.00001).

The first axis in the DCA analysis divides samples according to the moisture gradient, the second one – according to increasing vegetation cover (Fig. 2, Table 4). Although the cumulative percentage variance is quite low the results of the analysis clearly show that the soil is gathered by birds first of all from field roads and bulks, and to a lesser degree from arable fields. The nests contained no seeds of plant species connected with highly moist habitats, e.g. rushes and

Table 4. Spearman rank correlations of vegetation variables with axes of DCA diagram. Soil moisture was evaluated using weighted mean Zarzycki indicator value for soil humidity (specific values according to Zarzycki *et al.* 2002).

Vegetation variable	Correlation with axis 1	Correlation with axis 2
Soil moisture	0.91; P <0.0001	0.04; NS
Vegetation cover	0.4; P <0.01	0.73; P <0.001
Number of species	–0.26; NS	0.36; P <0.01

Molinia meadows, despite their closeness to the nests FM1 and FM4. Therefore, this dispersal mechanism may be significant first of all for weeds, ruderal species and species connected with field roads (*Lolio-Polygonetum arenastri* or the former *Lolio-Plantagginetum* association).

Birds tended to pick up soil mainly in the close vicinity of nests. This conclusion could be supported by the structure of the seed pool of the nests which had been taken down from clump of shrubs with the domination of *Sambucus nigra* (FM3, M1, M2). They contained a large amount of seeds of this species. The probability of their incorporation into the soil layer from the direct shedding from the bushes is very low, because of the existence of inner layers of nests. Additionally, no leftovers of fruits of *S. nigra* were found, only bare seeds. They must have got into the nests together with the soil, and so high a concentration of seeds indicated that it came from a very close vicinity of clumps of shrubs. It must have been the soil from the neighbouring road in the case of FM3 nest, and from the meadow in the case of the last two nests.

3.3. The potential role of nests in long distance dispersal

Although the number of the analysed nests was quite small, the results demonstrate that the transporting of diaspores with nest material may probably play a role in long distance seed dispersal, as well as, in the process of expansion of alien species. In the nest marked as F2, the seeds of two relatively rare species of foreign origin were found: *Diplotaxis tenuifolia* (kenophyte, origin – South and Western Europe, according to Tokarska-Guzik 2005) and *Erucastrum gallicum* (kenophyte, origin – South and Western Europe, according to Zając *et al.* 1998). During the study period, populations of these species were found only in the vicinity of the nest F2, but the distance between each of them and the location of the nest was in both cases higher than 100 m (approximately 120 m in the case of *E. gallicum* and more than 200 m in the case of *D. tenuifolia*). Moreover, the abundance of both populations was quite small: only one agglomeration of several dozens *D. tenuifolia* individuals was found in the country roadside, and several individuals of *E. gallicum* were noted in crop.

4. DISCUSSION

The role of animals in long distance seed dispersal is indisputable. Passive transport by attachment to fur or wool, dispersal by dung of grazing animals and active seed acquisition by birds or rodents are often mentioned in literature (Bakker *et al.* 1996 and literature cited there, Bruun and Poschold 2006). The mechanism of diaspore dispersal with bird nest material was described and evaluated less frequently. In our study we found seeds of more than seventy species belonging to different ecological groups (weeds and ruderal species are the most numerous groups). One nest may contain even a few hundreds of viable seeds. Dean *et al.* (1990) found 55 plant species incorporated into the nests of 31 bird species as lining and with structural material. The authors claim that some species with cottony seed covering are adapted for this dispersal mechanism.

The main problems arising during the study of this dispersal mechanism seem to be the longevity of nests and the longevity of seeds incorporated into the nest material. Dean *at al.* (1990) checked that the majority of nests disintegrated within a year, the small loosely constructed ones even after 1–2 months. Nests of Black-billed Magpie are more solid, but there is little information about their longevity. Birkhead (1991) observes only that they are extremely durable. The question arises, then, how many of seeds in a nest can remain alive till the moment of the nest's disintegration. There exist several commonly accepted assumptions concerning seed bank and the longevity of seeds, which can help to solve this problem. Species coming from strongly disturbed habitats usually have a persistent seed bank, in contrast to the species belonging to stable ecosystems. An increase of the level of disturbances, and thus the increase in mortality independent from population density, exerts a selective pressure on the increase of seed longevity. Thompson *et al.* (1998) noticed the decrease of values of the longevity index together with the decrease of the level of disturbances. The index value was highest in the case of arable fields and wastelands; it was lowest for meadows and forests. Seeds of annuals and biennials have the longest life span and seedling ability; their seed bank is more persistent than is the case of perennials related to them (Harper 1977, Thompson *et al.* 1998). Species from disturbed habitats dominated in the studied nests, hence they might keep their germination ability for several years. However, it seems that the study of nests' longevity and germination ability of seeds gathered there seems to be the main task for the future study of this mechanism of seed dispersal.

This mechanism can be also called the secondary dispersal, i.e. the process by which seeds that are already in the ground are moved to other locations (Wang and Smith 2002). The hypothesis that this process can influence such processes as colonisation of new habitats, range extension and succession, or spread of alien and invasive species (Cain *et al.* 2000, Howe and Miriti 2000, Wang and Smith 2002) can be confirmed by the present study. Seeds of two rare kenophytes, *Diplotaxis tenuifolia* and *Erucastrum gallicum*, were found in the nest material in considerable numbers. The migration of *D. tenuifolia* is mainly related to human activity: its unintentional introduction came with grain, and its migration takes place along railway tracks (Tokarska-Guzik 2005, Wrzesień 2006, Wrzesień and Święs 2006). The knowledge of the other species is much more limited. Probably it is in the beginning of its transition from the stage of ephemerophyte to kenophyte (Zając *et al.* 1998).

One of the advantages of seed dispersal is the direct dispersal to microsites crucial for establishment (Howe and Smallwood 1982, Howe and Miriti 2000). An example of this process is myrmecochory and consequences of dispersal by ants. Ant nests are nutrient enriched microsites (Westoby *et al.* 1990). Sometimes seeds with removed elaiosome with other waste materials are also relocated by ants to "garbage dumps" which provide better conditions for germination (Gorb S. and Gorb E. 1999, Gorb S. *et al.* 2000). Nest material can probably also contain higher concentrations of nitrogen and phosphorus compounds (for example because of moulting of fledgelings) and seeds can germinate on this substrate after the nests' disintegration. The next task for further studies is to check if secondary dispersal with nest material can be also treated as the placement of seeds in nutrient enriched microsite.

5. REFERENCES

Bakker J.P., Poschold P., Strykstra R.J., Bekker R.M., Thompson K. 1996 – Seed banks and seed dispersal: important topics in restoration ecology – Acta Bot. Neerl. 45 (4): 461–490.

Barnea A., Yom-Tov Y., Friedman J. 1992 – Effect of frugivorous birds on seed dispersal and germination of multi-seeded fruits – Acta Oecol. 13 (2): 209–219.

Birkhead T.R. 1991 – The magpies. The ecology of Black-billed and Yellow-billed Magpies – T & A D Poyser Ltd, London, 270 pp.

Beatty S.W. 1991 – Colonization dynamics in a mosaic landscape: the buried seed pool – J. Biogeogr. 18: 553–563.

Bruun H.H., Poschold P. 2006 – Why are small seeds dispersed through animal guts: large numbers or seed size per se? – Oikos, 113: 402–411.

Cain M.L., Milligan B.G., Strand A.E. 2000 – Long-distance seed dispersal in plant populations – Am. J. Bot. 87 (9): 1217–1227.

Dean W.R., Milton S.J., Siegfried W.R. 1990 – Dispersal of seeds as nest material by birds in semiarid karoo shrubland – Ecology, 7 (4): 1299–1306.
Debussche M., Isenmann P. 1994 – Bird-dispersed seed rain and seedling establishment in patchy Mediterranean vegetation – Oikos, 69: 414–426.
Eriksson O. 1996 – Regional dynamics of plants: a review of evidence for remnant, source-sink and metapopulations – Oikos, 77: 248–258.
Fahring L., Merriam G. 1992 – Conservation of fragmented populations – Conservation Biology, 8 (1): 50–59.
Gorb S.N., Gorb E.V. 1999 – Dropping rates of elaiosome-bearing seeds during transport by ants (*Formica polyctena* Foerst.): Implications for distance dispersal – Acta Oecol. 20 (5): 509–518.
Gorb S.N., Gorb E.V., Punttila P. 2000 – Effects of redispersal of seeds by ants on the vegetation pattern in a deciduous forest: a case study – Acta Oecol. 21 (4/5): 293–301.
Górska E., Górski W. 1997 – Nest sites of the Magpie *Pica pica* in urban and rural habitats in the Koszalin Region, NW Poland – Acta Orn. 32 (1): 45–50.
Górski W. 1997 – Urban and rural populations of the Magpie *Pica pica* in the Koszalin Region, NW Poland – Acta Orn. 32 (1): 51–60.
Harper J.L. 1977 – Population biology of plants – Academic Press, New York, 857 pp.
Higgins S.I., Nathan R., Cain M.L. 2003 – Are long distance dispersal events in plants usually caused by nonstandard means of dispersal? – Ecology, 84 (8): 1945–1956.
Howe H.F., Miriti M.N. 2000 – No question: seed dispersal matters. – TREE, 15 (11): 434–436.
Howe H.F., Smallwood J. 1982 – Ecology of seed dispersal. – Ann. Rev. Ecol. Syst. 13: 201–228.
Izhaki I., Ne'eman G. 1997 – Hares (*Lepus* ssp.) as seed dispersers of *Retama raetam* (Fabaceae) in a sandy landscape – J. Arid Env. 37: 343–354.
Merriam G. 1988 – Landscape dynamics in farmland – TREE, 3 (1): 16–20.
Mirek Z., Piękoś-Mirkowa H., Zając A., Zając M. 2002 – Flowering plants and pteridophytes of Poland. A checklist – W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków, 442 pp.
Nathan R.N., Muller-Landau H. C. 2000 – Spatial aptterns of seed dispersal, their determinants and consequences for recruitment – TREE, 15 (7): 278–285.
Nogales M., Delgado J.D., Medina F.M. 1998 – Shrikes, lizards and *Lycium intricatum* (Solanaceae) fruits: a case of indirect seed dispersal on an oceanic island (Alegranza, Canary Islands) – J. Ecol. 86 (5): 866–871.
Ouborg N.J., Piquot Y., van Groenendael J.M. 1999 – Population genetics, molecular markers and the study of dispersal in plants. – J. Ecol. 87 (4): 551–568.
Pulliam H.R. 1988 – Sources, sinks, and population regulation – Am. Nat. 132 (5): 652–661.
Ter Braak C.J.F., Šmilauer P. 2002 – CANOCO Reference manual and CanoDraw for Windows User's guide: Software for Canonical Community Ordination (version 4.5) – Microcomputer Power, Ithaca, NY, USA, 500 pp.
Thompson K., Bakker J.P., Bekker R.M., Hodgson J.G. 1998 – Ecological correlates of seed persistence in soil in the NW European flora – J. Ecol. 86 (1): 163–169.
Tokarska-Guzik B. 2005 – The establishment and spread of alien plant species (kenophytes) in the flora of Poland – Wyd. Uniw. Śląskiego, Katowice, 192 pp.
Wang B.C., Smith T.B. 2002 – Closing the seed dispersal loop. – TREE, 17 (8): 379–385.
Westoby M., Rice B., Howell J. 1990 – Seed size and plant growth form as factors in dispersal spectra – Ecology, 71 (4): 1307–1315.
Willerding Ch., Poschold P. 2002 – Does seed dispersal by sheep affect the population genetic structure of the calcareous grassland species *Bromus erectus*? – Biol. Conserv. 104: 329–337.
Wrzesień M. 2006 – Kenophytes chorologically related to the habitats of railway grounds in central eastern Poland – Biodiv. Res. Conserv. 1/2: 92–94.
Wrzesień M., Święs F. 2006 – Flora i zbiorowiska roślin naczyniowych terenów kolejowych zachodniej części Wyżyny Lubelskiej [Flora and vascular plants communities of raliway areas of western part of the Lublin Upland] – Wyd. UMCS, Lublin, 255 pp. (in Polish)
Zając A., Zając M., Tokarska-Guzik B. 1998 – Kenophytes in the flora of Poland: list, status and origin – Phytocoenosis 10 (N.S.), Suppl. Cartogr. Geobot. 9: 107–116.
Zarzycki K., Trzcińska-Tacik H., Różański W., Szeląg W., Wołek J., Korzeniak U. 2002 – Ecological indicator values of vascular plants of Poland – W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków, 183 pp.

Received after revising August 2008

APPENDIX

Structure of the s eed pool in the nests of Magpie *Pica pica.* Data obtained by seedling germination and seed extraction methods were summed up. Number of seeds per 1000 g of dry weight of soil. Codes of nests according to Table 2; asterisks indicates species which germinated from inner twig layer and lining; nomenclature of species after Mirek *et al.* 2002.

Taxa	Fields			Fields and meadows				Meadows	
	F1	F2	F3	FM1	FM2	FM3	FM4	M1	M2
Species connected with field roads									
Lolium perenne L.*	175	98	1	16	7	34	5		
Plantago major L.	4	24	5	14	15	20	2	4	3
Poa annua L.			1	4	2			1	1
Polygonum aviculare L.*		4	1	17	6		2		
Sporadic species: *Trifolium repens* L. F2									
Weeds									
Aethusa cynapium L.		2		1					
Amaranthus retroflexus L.	57	4		2	1		1		
Anagallis sp.	2	8			1		3		
Arenaria serpyllifola L.					3				
Atriplex patula L.				3					
Atriplex tatarica L.									2
Chamonilla suaveolens (Pursh) Rydb.		2		1					
Chenopodium album L.	3	48		21	34		1	1	
Echinochloa crus-galli (L.) P. Beauv.	1						1		
Euphorbia exigua L.		1					1		
Euphorbia helioscopia L.		1					1		
Euphorbia platyphyllos L.							2		
Fallopia convolvulus (L.) Á. Löve		1	1	2			1		
Galinsoga parviflora Cav.		1		2	1				
Galium aparine L.	4	1		1	1		2		
Papaver rhoeas L.	1	4		3	1		1		
Polygonum lapathifolium L. subsp. *pallidium* (With.) Fr					1		1		
Rumex crispus L.		2	1		1		1		
Setaria sp.	9				1		5		1
Sinapis arvensis L.	1	1	1				1		
Sonchus asper (L.) Hill	1						1		1
Sonchus oleraceus L.		16							
Stellaria media (L.) Vill.	1			1				1	1
Veronica persica Poir.				2			1		
Veronica polita Fr.		4		1					
Sporadic species: *Camelina microcarpa* Andrz. FM4, *Lithospermum arvense* L. FM4									
Ruderal species									
Arctium tomentosum Mill.		4			1				
Artemisia vulgaris L.*		13	3	4	1				

Taxa	Fields			Fields and meadows				Meadows	
	F1	F2	F3	FM1	FM2	FM3	FM4	M1	M2
Calamagrostis epigejos (L.) Roth)*		2							4
Capsella bursa-pastoris (L.) Medik.		1		6					
Conyza canadensis (L.) Cronquist		40			2				
Diplotaxis tenuifolia (L.) DC.		7	4		6				
Echium vulgare L.		5							
Erucastrum gallicum (Willd.) O. E. Schulz		8							
Lactuca serriola L.			2						
Medicago lupulina L.		5	2						
Melandrium album (Mill.) Garcke		1	1						1
Melilotus officinalis (L.) Pall.			3	1					
Picris hieracioides L.		1	1						
Poa compressa L.		2	2						
Reseda lutea L.		2							
Urtica dioica L.*				1		5		1	
Sporadic species: *Cirsium arvense* (L.) Scop. F3, *Senecio vulgaris* L. FM 1									
Meadow species									
Achillea millefolium L.*	1		1	6	2		1		1
Cerastium holosteoides Fr emend. Hyl.				4				1	
Daucus carota L.		6		2			3	1	1
Deschampsia caespitosa (L.) P. Beauv.								3	2
Glechoma hederacea L.				1				1	
Juncus articulatus L. emend K. Richt.							2	1	
Poa pratensis L.								3	1
Rumex acetosa L.		7							
Taraxacum officinale F. H. Wigg.	1	1						1	
Sporadic species: *Arrhenatherum elatius* (L.) P. Beauv. ex J. Presl & C. Presl F3, *Cardaminopsis arenosa* (L.) Hayek M1, *Dactylis glomerata* L. F2, *Epilobium parviflorum* Schreb. FM 4, *Galium mollugo* L. F3, *Hypericum perforatum* L. M1, *Lotus corniculatus* L. M1, *Pastinaca sativa* L. F2, *Scirpus sylvaticus* L. M2									
Bushes									
Cornus sanguinea L.*									7
Rosa sp.			3						
Sambucus nigra L.*			1	1	7	68		10	122
Sporadic species: *Prunus spinosa* L. F2									
Other species									
Carex hirta L.		1					1		1
Carex sp.							2		
Juncus bufonius L.			1						1
Juncus inflexus L.							3		
Other *Dicotyledones*								2	
Senecio sp.	3								
Solanum sp.*								1	1
Sporadic species: *Agrostis stolonifera* L. M1, *Betula pendula* Roth FM2, *Campanula trachelium* L. F2, *Carex vulpina* L. /*elata* All. FM 4, *Cyperus fuscus* L. M2, *Epilobium* sp. FM 1									