**Ornis Fennica 83:108–116. 2006**

# Comparison of methods for diet analysis and prey preference: a case study on the Red-backed Shrike *Lanius collurio*

Artur Goławski

*Department of Zoology, University of Podlasie, Prusa 12, 08-110 Siedlce, Poland. artgo1@ap.siedlce.pl*

*Received 21 December 2005, revised 27 February 2006, accepted 6 March 2006*

I studied diet composition and prey preferences of the Red-backed Shrike (*Lanius collurio*) in an extensive agricultural landscape in the eastern part of Poland. The diet composition of the Red-backed Shrike was described based on the analysis of animal remains in pellets (n = 968 prey items), larders (n = 115), butchering points (n = 1180) and nests (n = 79). Remains from all methods combined showed that Insecta predominated in the diet, comprising 98.9% of all prey items. Coleoptera prevailed decidedly (83.6%), followed by Hymenoptera (8.0%), Orthoptera (3.8%), Heteroptera (1.5%) and Diptera (1.1%). The proportions of the taxa in the diet of the Red-backed Shrike differed between the methods of food analysis, mainly with respect to Hymenopterans and Orthopterans. I found differences in the proportion of taxa between nests and butchering points, nests and larders and between animal remains in pellets and larders. I studied preference by comparing the proportions of potential prey of the Red-backed Shrike with the proportion of these prey items in their food. Red-backed Shrikes prefer beetles and Hymenopterans, and avoid Dipterans and Arachnids. The level of this preference differed depending on the methods of food analysis used.

## 1. Introduction

The Red-backed Shrike (*Lanius collurio*) is a threatened species, decreasing in numbers in Europe, especially to the west (Fornasari *et al*. 1997, BirdLife International 2004). Knowledge of the diet and food preferences of this species is very important for its protection (Kuper *et al*. 2000, Tryjanowski *et al*. 2003a). The diet composition of the Red-backed Shrike has been widely described (summary in Cramp & Perrins 1993, Lefranc & Worfolk 1997, Harris & Franklin 2000). Diet composition is known to vary geographically, but also locally due to seasonal or weather-dependent changes in prey abundance or availability (Cramp & Perrins 1993, Tryjanowski *et al.* 2003a). Other important factors are the biotope structure of the territory, and the agricultural management practice. Intensification of agricultural production, and use of pesticides, change the species structure of insect communities (Matson *et al.* 1997, Krooss & Schaefer 1998). Lastly, diet composition is known to be affected by the method of analysis (Tryjanowski *et al.* 2003b).

The aim of this study was to define the composition of the diet and the prey preferences of the Red-backed Shrike as studied with four methods of diet analysis. I emphasise the comparison of

these methods of analysing food. I conducted observations in an extensive agricultural landscape in eastern Poland, where division of farms and arable land into small fields has been preserved. The use of fertilisers and pesticides in this area is several times lower than in western Europe. Areas farmed with such methods are rare in Europe and differ distinctly even from the farmland of western Poland. It was probably the differences in farming intensity between these two parts of Poland that caused increases in numbers of many bird species, including the Red-backed Shrike, recorded in recent years in eastern Poland (Dombrowski *et al*. 2000, Dombrowski & Goławski 2002).

## 2. Material and methods

### 2.1. Study area

The studies were carried out in eastern Poland, near Siedlce (52°12' N; 22°17' E) in 1999–2003. The study area consisted of 855 ha of extensively agricultural landscape. Arable fields predominated in this area (53.5%), mainly with crops of rye and potatoes. The width of fields usually did not exceed 30m, and they were separated by baulks up to 1 m wide. The fields were crossed by a wide network of ground roads. Overdried meadows and pastures covered 21.1% of the area. Pastures were divided into sections for grazing cattle and usually fenced with barbed wire. Meadows were meliorated, and bushes, mainly willows *Salix sp*., grew in some places along ditches. The proportion of set-asides was 2.2%. Besides these open habitats, there were also woodlands and apple tree orchards. The structure of the land use did not change during the period of study. Red-backed Shrikes occupied open habitats at the edges of woodlands and orchards. More details on the studied population, including aspects of breeding ecology and densities, were published elsewhere (Goławski, in press).

### 2.2. Diet analysis

The diet composition of the Red-backed Shrike was defined based on the analysis of remains or whole animals found in pellets (n = 968 prey items), larders (places where the prey was stored, usually stabbed on thorns or barbed wire, n = 115), butchering points (places of processing prey, cutting wings and heads off, n = 1180) and in nests (n = 79) examined after they had been left by nestlings. I used only the material from pairs of Red-backed Shrikes for which data on their food was obtained from all four methods (10 pairs). During the five years, these pairs bred in 10 different places in the study area. Prey items were classified by an entomologist to the lowest possible taxon, and in this paper, like in many others (Hernández *et al*. 1993, Hernández 1995, Tryjanowski *et al*. 2003a) I classified these animals into orders. The number of invertebrates was determined based on the remains characteristic of a given taxon, i.e. heads, legs, parts or whole coverts. The number of vertebrates was determined according to the number of identified skulls, jaws, and if they were not found in a sample, long bones, humerus and femur, were considered.

All four methods of food analysis are non-invasive. These methods of food analysis did not cause any losses in broods, although this species is very susceptible to the presence of an observer and often abandons broods. Frequent visits of an observer to a nest can also increase predation pressure (Tryjanowski & Kuźniak 1999).

### 2.3. Available food

The Red-backed Shrike feeds mainly on invertebtrates and thus I used trapping methods suitable for this group of animals. I used two trapping methods. I caught invertebrates moving on the ground with pitfall traps, while those occurring in the upper zone of the vegetation I caught with an entomological catcher. I applied the standard routines while trapping insects with these two types of traps (Obrtel 1971, Johnson 1996). In each study site, I used 10 pitfall traps. The size of the trap entrance was 50 $cm^2$, so that in one site the trapping surface was 500 $cm^2$ in total. The size of the entomological catcher was 1017 $cm^2$, and in one site 50 catches were performed. I conducted trapping in 2003 in four types of open habitats, the main foraging places of Red-backed Shrikes: meadows, pastures, fallows and arable lands (crops of cereals and potatoes). In each of these habitats, within the

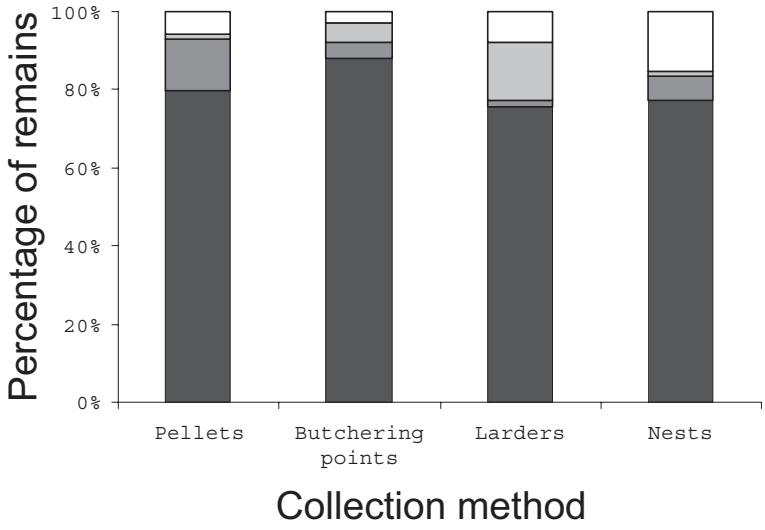


Fig. 1. The percentage of the taxa in the food of the Red-backed Shrike as analysed with four different methods. Taxa are from top to bottom: other (white), Orthoptera (light grey), Hymenoptera (dark grey), Coleoptera (black).

studied area, I established four catching sites 250–1,500 m apart, where I trapped invertebrates five times during the breeding season of the Red-backed Shrike between 27 May and 15 July. These trapping sites included habitats occurring in territories of Red-backed Shrikes, but not all of them were part of certain territories. Location of some of the trapping sites outside Red-backed Shrike territories resulted from brood losses at the early stage of breeding and abandoning nesting places by birds. This took place after the first period of catching and in such cases I did not change the catching location. Both methods of trapping of invertebrates were used on the same day. I classified trapped invertebrates into orders (except for Myriapoda). I omitted animals smaller than 4 mm, as in the food of the Red-backed Shrike animals longer than 4 mm have been almost exclusively found (Hernández 1993, Lefranc & Worfolk 1997). Among the animals I distinguished a separate category "larvae", i.e. larval stages of all invertebrates jointly, not dividing them into orders.

### 2.4. Prey preferences

To determine which taxa of animals were preferred by the Red-backed Shrike, I used the selectivity index D (Jacobs 1974). This method consists of comparing the proportion of taxa consumed by a bird with the proportion of taxa available in its territory, and is described by the formula D = (r–p)/(r+p–2*p). Here, r denotes the fraction of a given taxon of invertebrates of the total number of invertebrates identified from some method of food analysis, and p the fraction of a taxon of invertebrates in the potential food. D varies from –1 (negative selection) to 0 (catching proportional to abundance) to +1 (positive selection).

The number of invertebrates potentially occurring in a territory of the Red-backed Shrike were based on proportions of the four types of open habitats in the birds' territories. I calculated proportions of these habitats with a planimeter according to the map of a territory drawn in the field. As a territory of the Red-backed Shrike, I assumed a circle of 70 m radius with the centre at the location of the birds' nests. The obtained area of 1.54 ha is in accordance with an average territory size in this species, as described in the literature (Cramp & Perrins 1993, Lefranc & Worfolk 1997).

Knowing the abundance of subsequent invertebrate taxa in certain habitats I calculated the theoretical number composition of taxa in each territory. Next, I compared it with the composition of taxa in these territories known from the analysis of food of the Red-backed Shrike. I considered only the taxa of invertebrates present in the material from catches and from the food analysis. I excluded those taxa which were represented in catches by single specimens, i.e. Myriapoda and Deramaptera.

I compared the food composition of the Red-backed Shrike studied with the four methods using

G tests (Sokal & Rohlf 2001). I considered results statistically significant with a probability limit of 0.05.

## 3. Results

### 3.1. Diet composition

In the diet of the Red-backed Shrike, according to the data from all four methods combined, insects predominated, comprising 98.9% of the number of all prey. Coleoptera prevailed (83.6%), followed by Hymenoptera (8.0%), Orthoptera (3.8%), Heteroptera (1.5%) and Diptera (1.1% of the number of prey). The proportion of Lepidoptera, Dermaptera or Odonata was below 1% of the total number of prey. Among vertebrates I found Mammalia, Aves and Amphibia which comprised 0.6% of the prey. In the food of the Red-backed Shrike I noted also Myriapoda, Araneae, Oligochaeta, Gastropoda, which jointly amounted to 0.5% of all prey items.

The proportions of taxa in the diet of the Red-backed Shrike differed between the methods of collecting food (Fig. 1). The greatest differences occurred in the proportions of taxa in animal remains between nests and butchering points (G-test, $G_{12} = 24.4$, $P = 0.018$) and between nests and larders ($G_{12} = 20.8$, $P = 0.050$). The proportions of taxa in the food obtained from the analysis of remains in nests and in pellets did not differ significantly ($G_{12} = 20.6$, $P > 0.050$). I further observed differences in food composition between animal remains from pellets and larders ($G_{12} = 31.0$, $P = 0.002$), but no such differences with butchering points ($G_{12} = 11.0$, $P > 0.050$). No differences in the proportions of taxa between larders and butchering points were found ($G_{12} = 1.7$, $P > 0.050$).

With respect to the more numerous taxa, distinct differences in their proportions among prey caught at the different sites occurred for Hymenopterans, Orthopterans, Dipterans and vertebrates.

### 3.2 Prey availability and preferences

In an average territory of the Red-backed Shrike, the dominant number of potential prey caught with pitfall traps were Arachnids and beetles that jointly comprised over 85% of all invertebrates. The remaining taxa did not exceed 10% (Table 1). In trapping with the catcher, the proportions of the dominant taxa were more balanced (Table 2). I compared numbers of invertebrate taxa within the same habitat and catching date, but these differed only in 3 out of 20 cases (chi-square test). Hence, catches of invertebrates did not have a decisive influence on calculations of food preferences.

The proportion of the different taxa available (i.e. caught with pitfall traps and the entomological catcher) differed significantly from the proportion of the same taxa in the diet of the Red-backed Shrike, based on all four collecting sites combined (G-test, in all cases $P < 0.001$).

In an average territory of the Red-backed Shrike ($n = 10$) the proportion of meadows was 37.8% (SD = 39.83), pastures 12.5% (SD = 27.62), fallow land 2.5% (SD = 5.57) and arable fields 47.2% (SD = 44.22). When comparing the proportions of taxa caught in territories using pitfall traps with their proportion in the birds' prey, beetles and Hymenopterans were most preferred. Arachnids and Dipterans were avoided. However, only beetles were preferred and Dipterans were omitted in all the methods of food analysis of the Red-backed Shrike (Table 3). With respect to the remaining taxa, some differences in food preferences occurred, depending on the methods of food analysis used (Table 3). The percentage of taxa trapped with the catcher in territories compared with their percentage in the diet indicated the Shrikes preference for beetles and Hymenopterans, and avoidance of Arachnids, Orthopterans, Heteropterans, Lepidopterans and Dipterans. In all the methods of food analysis beetles and Hymenopterans were preferred, while Orthopterans, Heteropterans, Dipterans and Arachnids were avoided (Table 3).

## 4. Discussion

### 4.1. Diet composition

Researchers have collected an impressive amount of information about the diet of the Red-backed Shrike. Results show that the diet of this species can differ significantly depending on the methods used in studies on the composition of its prey

Table 1. The mean number and SD of groups of invertebrates in four types of habitats caught with pitfall traps in eastern Poland.

| Taxa | Pitfall traps | | | |
|---|---|---|---|---|
| | Meadows | Pastures | Fallow land | Arable fields |
| *Coleoptera* | 41.1 ± 31.32 | 15.1 ± 13.72 | 17.2 ± 5.41 | 20.1 ± 10.51 |
| *Orthoptera* | 3.7 ± 3.66 | 3.0 ± 2.13 | 5.9 ± 4.20 | 2.4 ± 1.69 |
| *Lepidoptera* | 0.8 ± 0.83 | 0.8 ± 0.72 | 0.6 ± 0.89 | 0.6 ± 0.89 |
| *Heteroptera* | 0.4 ± 0.49 | 0.3 ± 0.47 | 0.4 ± 0.49 | 1.6 ± 1.43 |
| *Hymenoptera* | 2.3 ± 2.00 | 1.6 ± 2.16 | 3.8 ± 2.42 | 3.3 ± 3.14 |
| *Diptera* | 2.1 ± 1.90 | 2.5 ± 1.93 | 3.8 ± 3.29 | 2.1 ± 1.80 |
| Other *Insecta* | 2.1 ± 2.97 | 2.2 ± 2.25 | 1.6 ± 1.90 | 2.2 ± 1.95 |
| *Araneae* | 42.3 ± 34.85 | 50.8 ± 44.94 | 16.1 ± 13.78 | 11.1 ± 7.65 |
| Other *Invert.* | 0.5 ± 1.00 | 0.3 ± 0.55 | 0.4 ± 0.75 | 0.1 ± 0.31 |
| Total | 95.1 ± 52.89 | 76.4 ± 55.24 | 49.5 ± 15.69 | 43.2 ± 12.68 |

Table 2. The mean number and SD of groups of invertebrates in four types of habitats caught with the entomological catcher in eastern Poland.

| Taxa | Entomological catcher | | | |
|---|---|---|---|---|
| | Meadows | Pastures | Fallow land | Arable fields |
| *Coleoptera* | 4.2 ± 3.83 | 2.7 ± 1.22 | 5.0 ± 4.12 | 4.6 ± 3.55 |
| *Orthoptera* | 6.0 ± 4.27 | 6.4 ± 7.12 | 9.1 ± 3.97 | 3.1 ± 2.11 |
| *Lepidoptera* | 0.4 ± 0.50 | 0.4 ± 0.60 | 0.9 ± 1.35 | 0.3 ± 0.47 |
| *Heteroptera* | 6.8 ± 4.23 | 5.3 ± 2.77 | 7.6 ± 3.89 | 7.6 ± 4.48 |
| *Hymenoptera* | 0.4 ± 0.59 | 0.2 ± 0.44 | 0.3 ± 0.57 | 0.2 ± 0.44 |
| *Diptera* | 1.7 ± 1.76 | 2.3 ± 2.30 | 1.1 ± 1.15 | 0.7 ± 0.57 |
| Other *Insecta* | 2.2 ± 1.98 | 2.4 ± 2.37 | 2.2 ± 2.80 | 2.1 ± 3.31 |
| *Araneae* | 2.1 ± 2.31 | 1.8 ± 1.88 | 3.2 ± 3.29 | 2.4 ± 2.52 |
| Other *Invert.* | 0.0 ± 0.00 | 0.1 ± 0.22 | 0.1 ± 0.31 | 0.0 ± 0.00 |
| Total | 23.8 ± 9.81 | 21.7 ± 8.44 | 29.5 ± 7.62 | 21.1 ± 9.30 |

Table 3. The proportion of invertebrate groups in an average shrike territory (PT – pitfall traps, C – entomological catcher) and Jacobs index of food preferences. Explanations: P – pellets, B – butchering points, L – larders, N – prey remains in nests, T – total.

| Taxa | Pitfall traps | | | | | | Entomological catcher | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PT | P | B | L | N | T | C | P | B | L | N | T |
| Coleoptera | 0.420 | +0.70 | +0.82 | +0.66 | +0.81 | +0.76 | 0.209 | +0.88 | +0.93 | +0.86 | +0.92 | +0.91 |
| *Orthoptera* | 0.047 | –0.60 | +0.04 | +0.57 | –0.55 | –0.10 | 0.236 | –0.92 | –0.70 | –0.27 | –0.91 | –0.77 |
| *Lepidoptera* | 0.010 | –0.54 | +0.00 | +0.29 | –1.00 | –0.18 | 0.018 | –0.72 | –0.29 | +0.00 | –1.00 | –0.44 |
| *Heteroptera* | 0.014 | +0.32 | –0.56 | –0.22 | +0.36 | +0.03 | 0.347 | –0.90 | –0.98 | –0.97 | –0.89 | –0.94 |
| *Hymenoptera* | 0.042 | +0.56 | +0.01 | –0.41 | +0.27 | +0.34 | 0.009 | +0.89 | +0.66 | +0.34 | +0.79 | +0.81 |
| *Diptera* | 0.034 | –0.27 | –0.80 | –0.59 | –0.43 | –0.52 | 0.061 | –0.54 | –0.89 | –0.77 | –0.66 | –0.72 |
| *Araneae* | 0.431 | –1.00 | –0.99 | –0.95 | –1.00 | –0.99 | 0.110 | – | –0.95 | –0.74 | –1.00 | –0.97 |

(Tryjanowski *et al*. 2003b). Among the methods of food analysis that I applied in this study, analyses of food remains found in butchering points have been the rarest in the literature. In the only study that used this method, most of the prey recorded were beetles, while the percentage of other taxa did not exceed 1% (Randik 1970). Descriptions of the diet composition based on remains of animals found in nests have been deficient as well. In these results, beetles and Hymenopterans predominated (Randik 1970, Olsson 1995), but Mansfeld (1958) stated also a remarkable (11%) proportion of rodents.

Numerous studies describe the composition of food collected in larders. In these results a distinct domination of beetles and Hymenopterans has been described (Mielewczyk 1967, Randik 1970, Lefranc 1979). Nevertheless, in Spain the domination of Orthopterans was found (Hernández 1995). Using this method, also a relatively high participation of vertebrates was found (Lefranc 1979, Olsson 1995), which reached in extreme cases 35% of the number of all prey items (Mielewczyk 1967, Knysh 2001).

The most abundant published reports on the diet of the Red-backed Shrike come from analysis of pellets. In many locations within the breeding range of this shrike, beetles and Hymenopterans were the most common prey item (Mann 1983, Hernández 1993, Wagner 1993, Olsson 1995, Kuper *et al*. 2000, Tryjanowski *et al*. 2003b, Karlsson 2004). Besides these two orders, other dominant taxa (>5% of prey) were Heteropterans (Hernández 1993, Tryjanowski *et al*. 2003b), Orthopterans (Hernández *et al*. 1993, Wagner 1993, Karlsson 2004), and even Dermapterans (Olsson 1995).

All the presented methods of analysis of the Red-backed Shrike diet showed the domination of two orders of insects, Coleoptera and Hymenoptera, in the diet. In my studies, conducted in an extensive agricultural landscape, the domination of these two taxa was clear as well. In comparison with the literature data (e.g. Randik 1970), in the present study I stated super-domination of Coleoptera. It is also a little surprising that I found a relatively high percentage of vertebrates in nests, in comparison with other methods of food analysis. I also observed the several-percent proportion of Orthopterans at butchering points and a low proportion of Hymenopterans in larders (vs. Randik 1970).

### 4.2. Prey preferences

The prey preferences of the Red-backed Shrike have rarely been studied. In western Poland, according to the data collected with different methods, Tryjanowski *et al*. (2003a) described preferences for beetles, Hymenopterans and Orthopterans, while Heteropterans were avoided. In Spain, based on the analysis of animal remains in pellets it appeared that beetles and Hymenopterans were preferred as well, but Orthopterans, Heteropterans and Arachnids were avoided (Hernández *et al*. 1993). It has been emphasised that it is easier to obtain a correlation between the available food and the food used by birds in the situation where prey is limited (Hornman *et al*. 1998, Kuper *et al*. 2000). Limitations of each method play some role as well. In studies of the food based on remains of animals in pellets, the percentage of some taxa may be overestimated, as they are better preserved in pellets – this concerns animals with strongly chitinised bodies. Clearly, beetles can be included in this category (Tryjanowski *et al*. 2003b).

I found in a Polish population of Red-backed Shrikes that they prefer beetles and Hymenopterans. Thus, the obtained results are generally consistent with those obtained by other authors (Hernández *et al*. 1993, Tryjanowski *et al*. 2003a). There are a number of possibilities to explain the Red-backed Shrike's preferences for these taxa. Firstly, all of these taxa consist of animals with a relatively large body size. Larger prey have high protein content, thus catching one big animal probably allows the parents to earn some energy in comparison with hunting a few smaller prey items (Lepley *et al*. 2004). Second, bigger animals are more visible and move slower and thus they are easier to catch (Brodmann & Reyer 1999). Lastly, the method of catching the potential prey may not reflect its availability for birds (Poulin & Lefebvre 1997). Studying the potential food of the Water Pipit (*Anthus spinoletta*) with as many as five methods, Brodmann and Reyer (1999) concluded that with only two methods they caught the taxa provided to nestlings. To represent the food available to the Red-backed Shrike completely, insects

should be caught also in flight, but this was technically extremely difficult. Red-backed Shrikes can catch insects in flight to a large extent (Moskát 2001, Karlsson 2004).

In eastern Poland, Red-backed Shrikes prefer mainly the same taxa when their diet was compared both with the numbers of invertebrates caught with the pitfall traps and the entomological catcher. However, the proportions of taxa differed decidedly between these two trapping methods. Hence, if the obtained results were not biased by the limitations of the methods of studying the birds' diet composition, it seems that these two orders of insects (Coleoptera and Hymenoptera) were indeed taken by Red-backed Shrikes more frequently than would result from their proportional abundance in insect communities in the studied area. It is somewhat surprising that shrikes avoid Orthopterans, which are large in body size. However, Orthopterans occur relatively late in the breeding season of the Red-backed Shrike (from the end of May) and may therefore be absent in a part of the collected material (Karlsson 2004). Tryjanowski *et al*. (2003a) stated that the preference or avoidance of Orthopterans in food might be due to local conditions. Shrikes can use their larders not only for food storage and dividing food into portions, but larders also play an important role in the shrikes' communication and mating system (Antczak *et al*. 2005). Furthermore, the potential prey caught with different methods is not always the same available to birds. The problem of availability and abundance of prey has been studied also in shrikes. Differences in the diet of chicks of the Red-backed Shrike between spring and summer were probably caused by prey availability in these two periods (Hernández 1993). Availability of potential prey plays a very important role in selection of a territory (Tryjanowski et al. 1999). Shrikes typically prey on terrestrial animals, and therefore prefer sites with low vegetation. Changes in vegetation height (e.g. mowing) cause changes in food composition and the hunting technique (Yosef & Grubb 1993).

I trapped the potential prey of the Red-backed Shrike during one year only, while its diet composition was studied during five years, and this might affect the obtained results. Undoubtedly, the occurrence of different invertebrate taxa during the season changes from year to year. An important factor decisive for the timing of their occurrence is weather conditions (e.g. for Orthopterans). The mean daily temperature and precipitation did not differ statistically between all the seasons (respectively: ANOVA; $F_{4,40} = 0.64$, $P = 0.99$ and Kruskal-Wallis Test: $H_4 = 0.47$, $P = 0.98$, calculated based on the decade means). Besides the influence of weather conditions, the numbers of invertebrates in the breeding period of the Red-backed Shrike can also be affected by, for example, weather conditions in winter (which would affect survival of eggs and larval stages). Location of some places of catching invertebrates outside territories of the Red-backed Shrike could also influence the results. However, in most cases on the same catching date various habitats did not differ statistically significantly, which minimised any potential bias in the results. Habitats differed in numbers of caught invertebrates only in three cases. These discrepancies resulted probably from a different time of beginning of mowing of meadows, as they considered only the first and second dates of catching. They could also be caused by differences in the beginning of cattle grazing, which influenced the height of vegetation in pastures as well. Outside these habitats differences in numbers of caught animals occurred on fallow land in trapping with the entomological catcher. This was probably caused by differences in the vegetation height during the last catching of invertebrates.

Based on the obtained results, it can be stated that investigations on the diet composition based on the animal remains in pellets and the remains found in nests give similar results. Most probably it is so because remains of prey from chafed pellets of nestlings stay in nests. The diet of nestlings of the Red-backed Shrike changes with their age. In their first days of life a remarkable proportion of the chicks diet are Araneae and Lepidoptera (Hernández 1993), and these taxa are very poorly preserved in pellets. Thus, the diet composition of nestlings should be studied with other methods, e.g. collars (an invasive method, Tryjanowski *et al*. 2003b), observations from a hide (Hornman *et al*. 1998) or use of cameras (Favini *et al*. 1998). The analysis of the diet of the Red-backed Shrike based on prey remains from butchering points and larders give different results than the two other methods. Moreover, the food compositions based

on analyses of prey found in butchering points and larders are similar. The latter two methods are suitable to state mainly the presence of a large prey, such as beetles and Orthopterans, in the food of the Red-backed Shrike.

*Acknowledgements.* I am grateful to Włodzimierz Meissner and Cezary Mitrus for their comments to the manuscript. The prey composition in the food of the Red-backed Shrike was identified by Zbigniew Mocarski. The financial support was provided by the University of Podlasie (grant 75/94/S). I am grateful for valuable suggestions from S. Karlsson and an anonymous reviewer.

**Ravintoanalyysimenetelmien vertailua: tapaus pikkulepinkäinen**

Tutkin ravinnon koostumusta ja saalismieltymyksiä pikkulepinkäisellä maatalousmaisemassa Itä-Puolassa. Ravinnon koostumus määritettiin laskemalla saaliseläinten jäänteet oksennuspalloista (968 saaliseläintä), ravintovarastoista (115), teurastuspaikoista (1180) ja pesistä (79). 98.9 % kaikista saaliseläinmistä oli hyönteisiä. Kovakuoriaisia saaliista oli 83.6 %, pistiäisiä 8.0 %, suorasiipisiä 3.8 %, luteita 1.5 % ja kaksisiipisiä 1.1 %. Saaliseläinten osuudet kokonaissaalismäärästä vaihtelivat analysointimenetelmästä riippuen lähinnä pistiäisten ja suorasiipisten välillä. Löysin eroja saalislajiston esiintymisessä pesien ja teurastuspaikkojen, pesien ja ruokavarastojen sekä oksennuspallojen ja ruokavarastojen välillä. Vertasin pikkulepinkäisen potentiaalisten saaliseläinten määrää niiden osuuteen kokonaissaaliista. Pikkulepinkäiset suosivat kovakuoriaisia sekä pistiäisiä ja välttelevät kaksisiipisiä ja hämähäkkejä.

## References

Antczak, M., Hromada, M. & Tryjanowski, P. 2005: Spatio-temporal changes in Great Grey Shrike Lanius excubitor impaling behaviour: from food catching to communication signs. — Ardea 93: 101–107.

BirdLife International. 2004: Birds in Europe: population estimates, trends and conservation status. — BirdLife International, Cambridge.

Brodmann, P.A. & Reyer, H.-U. 1999: Nestling provisioning in water pipits (Anthus spinoletta): do parents go for specific nutrients or profitable prey? — Oecologia 120: 506–514.

Cramp, S. & Perrins, C.M. 1993: Red-backed Shrike, Lanius collurio. — Handbook of the Birds of Europe the Middle East and North Africa, vol. 7. — Oxford University Press, Oxford, New York.

Dombrowski, A. & Goławski A. 2002: Changes in numbers of breeding birds in an agricultural landscape of east-central Poland. — Vogelwelt 123: 79–87.

Dombrowski, A., Goławski, A., Kuźniak, S. & Tryjanowski, P. 2000: Status and threats of the Red-backed Shrike Lanius collurio population in Poland. — Notatki Ornitologiczne 41: 139–148. (In Polish with English summary)

Favini, G., Fornasari, L., Bottoni, L. & Massa, R. 1998: A video-taping approach to study nestling diet and parental care of Red-backed Shrike *(*Lanius collurio). — IBCE Tech. Publ. 7: 76–78.

Fornasari, L., Kurlavičius, P., Massa, R. 1997: Red-backed Shrike, Lanius collurio. — In: The EBCC Atlas of European Breeding Birds: Their Distribution and Abundance (ed. Hagemeijer, W.J.M. & Blair, M.J.): 660–661. T & A D Poyser, London.

Goławski, A. 2006: Breeding biology of the Red-backed Shrike Lanius collurio in extensive agricultural landscape in eastern Poland. — Notatki Ornitologiczne 47: 1–10. (In Polish with English summary)

Harris, T. & Franklin, K. 2000: Shrikes and Bush-Shrikes. — Christoper Helm, London.

Hernández, A. 1993: Nestling diet of three sympatric shrike species (Lanius spp.): age-related, seasonal, and interspecific variations. — Doñana, Acta Vertebrata 20: 145–163. (In Spanish with English summary)

Hernández, A. 1995: Temporal-spatial patterns of food caching in two sympatric Shrike species. — Condor 97: 1002–1010.

Hernández, A., Purroy, F.J. & Salgado, J.M. 1993: Seasonal variation, interspecific overlap, and diet selection in three sympatric shrike species (Lanius spp.). — Ardeola 40: 143–154. (In Spanish with English summary)

Hornman, M., Nijssen, M., Geertsma, M., Kuper, J. & Esselink, H. 1998: Temporal effects on diet composition in nestling Red-backed Shrike (Lanius collurio) in Bargerveen, the Netherlands. — IBCE Tech. Publ. 7: 83–87.

Jacobs, J. 1974: Quantitative measurement of food selection. A modification of the forage ratio and Ivlev's index. — Oecologia 14: 413–417.

Johnson, S.R. 1996: Spiders associated with early successional stages on a Virginia Barrier Island. — Journal of Arachnology 24: 135–140.

Karlsson, S. 2004: Season-dependent diet composition and habitat use of Red-backed Shrikes Lanius collurio in SW Finland. — Ornis Fennica 81: 97–108.

Knysh, N.P. 2001: About pinning (caching) of prey by Red-backed Shrike. — Berkut 10: 218–225. (In Russian with English summary)

Krooss, S. & Schaefer, M. 1998: The effect of different farming systems on epigeic arthropods: a five-year study on the rove beetle fauna (Coleoptera: Staphylinidae) of winter wheat. — Agriculture, Ecosystems and Environment 69: 121–133.

Kuper, J., van Duinen, G.-J., Nijssen, M., Geertsma, M. & Esselink, H. 2000: Is the decline of the Red-backed Shrike (Lanius collurio) in the Dutch coastal dune area caused by a decrease in insect diversity? — Ring 22, 1: 11–25.

Lefranc, N. 1979: Contribution to the ecology of Lanius collurio in the Vosges Moyennes. — Oiseau 49: 245–298. (In French)

Lefranc, N. & Worfolk, T. 1997: Shrikes. A Guide to the Shrikes of the World. — Pica Press, Sussex.

Lepley, M., Ranc, S., Isenmann, P., Bara, T., Ponel, P. & Guillemain, M. 2004: Diet and gregarious breeding in Lesser Grey Shrike Lanius minor in Mediterranean France. — Revue d'Ecologie 59: 591–602.

Mann, W. 1983: On the food of the Red-backed Shrike in relation to the insect availability on different types of grassland. — Vogelkundliche Hefte Edertal 9: 5–41. (In German)

Mansfeld, K. 1958: On the food of the Red-backed Shrike (Lanius collurio collurio L.), especially on the food of the nestlings, extermination of useful and noxious insects and its influence on Passerine population. — Beitrage Vogelkundliche 6: 270–292. (In German)

Matson, P.A., Parton, W.J., Power, A.G. & Swift, M.J. 1997: Agricultural intensification and ecosystem properties. — Science 277: 504–509.

Mielewczyk, S. 1967: On the food of the Red-backed Shrike, Lanius collurio L., near Gniezno (prov. of Poznań). — Acta Ornithologica 10: 157–175. (In Polish with English summary)

Moskát, C. 2001: Changes in the frequency of hunting techniques in the Red-backed Shrike Lanius collurio during the breeding season. — Ornis Hungarica 11: 33–36.

Obrtel, R. 1971: Number of pitfall traps in relation to structure of the catch of soil surface Coleoptera. — Acta Entomologica Bohemoslovaca 68: 300–309.

Olsson, V. 1995: The Red-backed Shrike Lanius collurio in southeastern Sweden: Habitat and territory. — Ornis Svecica 5: 31–41.

Poulin, B. & Lefebvre, G. 1997: Estimation of arthropods available to birds: effect of trapping technique, prey distribution, and bird diet. — Journal of Field Ornithology 68: 426–442.

Randik, A. 1970: Red-backed Shrike (Lanius collurio) in natural conditions of Slovakia. — Prace a studie COP pri SUPSOPB Bratislava, 3: 1–132. (In Slovak with English summary)

Sokal, R.R. & Rohlf, F.J. 2001: Biometry. — Freman and Co., New York.

Sőderstrőm, B. 1999: Territory preferences and reproductive performance of Red-backed Shrikes Lanius collurio in farmland grasslands. — Doctoral thesis, Dept. of Conservation Biology, SLU, Uppsala.

Tryjanowski, P., Hromada, M. & Antczak, M. 1999: Breeding habitat selection in the Great Grey Shrike Lanius excubitor – the importance of meadows and spring crops. — Acta Ornithologica 34: 59–63.

Tryjanowski, P., Karg, M.K. & Karg, J. 2003a: Diet composition and prey choice by the red-backed shrike Lanius collurio in western Poland. — Belgian Journal of Zoology 133: 157–162.

Tryjanowski, P., Karg, M.K. & Karg, J. 2003b: Food of the Red-backed Shrike Lanius collurio: a comparison of three methods of diet analysis. — Acta Ornithologica 38: 59–64.

Tryjanowski, P. & Kuźniak, S. 1999: Effect of research activity on the success of Red-backed Shrike Lanius collurio nests. — Ornis Fennica 76: 41–43.

Wagner, T. 1993: Seasonal change in diet composition of the Red-backed Shrike (Lanius collurio). — Journal für Ornithologie 134: 1–11. (In German with English summary)

Wojewódzki Urząd Statystyczny. 1995: The environment protection in Voivodeship of Siedlce. — WUS, Siedlce. (In Polish)

Yosef, R. & Grubb, T.C., Jr. 1993: Effect of vegetation height on hunting behaviour and diet of Loggerhead Shrikes. — Condor 95: 127–131.