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Source: Acta Ornithologica, 38(1) : 59-64

Published By: Museum and Institute of Zoology, Polish Academy of Sciences

URL: https://doi.org/10.3161/068.038.0101

ACTA ORNITHOLOGICA
Vol. 38 (2003) No. 1

Food of the Red-backed Shrike *Lanius collurio*: a comparison of three methods of diet analysis

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

Abstract. Diet of the Red-backed Shrike was analysed from collars in nestlings, pellets and prey remains in larders. All the material was collected from the same territories in Western Poland. A total of 2855 prey items were identified from all samples. Insects, mainly Coleoptera, Hymenoptera and Orthoptera constituted 98.9% of all prey items identified. To determine diet and predict impact of food sources on Red-backed Shrike populations, three methods should be used together (pellet content analyses, collar sampling and analysing larders). Our findings suggest that pellet content analyses is an easy and non-invasive method for estimating prey diversity and frequency index. Collars are necessary to determine nestling diets. Analyses of prey remains in larders should be used to find large prey, handled before eating. In more advanced geographical analysis of the content of shrike diet, we suggested to pool together data obtained by different methods from the same place, and/or carefully assign methods of diet analyses.

Key words: Red-backed Shrike, *Lanius collurio*, diet analysis, methods

Received — March 2003, accepted — May 2003

INTRODUCTION

Many papers have focused on the food composition and foraging ecology of the Red-backed Shrike (review in Van Nieuwenhuyse et al. 1999, Harris & Franklin 2000). Its diet is predominately composed of insects; it is sometimes supplied by vertebrates (Lefranc & Worfolk 1997, Harris & Franklin 2000). There are, however, difference in the importance of particular insect taxa in the diet. Some of these differences have a natural character (e.g., geographical location, habitat quality), some others can result from different assessments of Red-backed Shrike diet.

Therefore, the aim of this study is to test differences between three various methods aimed in describing Red-backed Shrike diet.

MATERIAL AND METHODS

Study area

The research was carried out from May to August 1999–2000 in an area situated about 50 kilometres south of Poznań. The region is dominated by agricultural lands and habitats include cultivated fields (80%), small forests (15%), marshland (3%) and inhabited areas. Most Red-backed Shrikes arrived there in early May, start breeding between half of May and the half of June (Tryjanowski & Kuźniak 1999, Tryjanowski et al. 2000), and leave the study area in September or October. The area considered in this study was ca 60 km^2, with a mean density 1.1–1.4 breeding pairs/1km^2. Further details on the study area and biology of the Red-backed Shrike population living there are given by Kuźniak & Tryjanowski (2000) and Tryjanowski et al. (2000).

Analysis of nestling food

Nestling food was assessed by collar samples when the young were 5–10 days old. After every two to three feeding visits of the parents, the food was removed from the nestlings' throats with forceps. The arthropods were preserved in 70% ethanol and identified to family level, according to reference collection obtained in the same study area (J. Karg, unpublished data).

Pellet analysis

Pellets were collected from 17 shrike territories. A total of 3954 prey items were identified (at least to family level) in 336 pellets. For more detailed comparison we only used data from 193 pellets collected from theses in 12 territories, where food from nestlings was obtained. Pellets were analysed with standard procedure (Rosenberg & Cooper 1990). Most of prey items were identified using the reference collection. Diagnostic remains of insects (e.g., head-capsules, mandibules, legs, clyppeus, abdoben, coverts etc.) found in pellets were isolated, identified and counted. Since each diagnostic fragment did not necessarily come from a different individual, a correction factor was applied. The number derived from the count of legs was divided by six, unless they formed the specialised pair (e.g. fore legs of crickets, hind legs of grasshoppers), in which case they were divided by two. Each head-capsule and distal segment of the abdomen (i.e. telson) each represented one individual prey item. Values obtained after applying the correction factors were compared and the highest value was considered as the estimate of the number of insects eaten (Calver & Wooller 1982). This comparison was done for each insect taxon (species, genus or family) of present in pellets.

Larders

We also controlled larders and butchering points, where the shrikes prepare food for nestlings, as well as for themselves (Lefranc & Worfolk 1997). We used data from 14 points located in the same territories as nest where collars data were obtained.

Calculations and statistics

Statistical analyses were carried out using compositional analysis on the six numerically dominant taxa: beetles (Coleoptera), bees and wasps (Hymenoptera), orthopterans (Orthoptera), bugs (Heteroptera), vertebrates (Vertebrata) and a category containing all the remaining taxa referred to as "others" (moths and butterflies Lepidoptera, flies Diptera, spiders Araneae and many others; for detail see Karg 2001).

We compare frequency of distinct food categories using G-test (Zar 1999).

We compared differences between food category frequencies expressed by three methods. For the following most important prey orders (Hymenoptera, Coleoptera, Orthoptera, Diptera and Lepidoptera). To reduce variances, percentage data were arcsine transformed before analyses. When assumptions of normality were met (in all cases) consequently one-way ANOVA were used to compare three methods of diet analyses (Zar 1999).

RESULTS

A total of 66 prey items were collected from 12 nests. Wet mass of food portion taken from one nestling varied from 0.53 to 5.63 g (mean ± SD = 2.25 ± 1.28 g, n = 56). Dry mass of pellets ranged from 0.55 to 6.53 g (mean ± SD = 1.74 ± 0.88 g, n = 159). A total of 594 prey items from larders were identified.

Diet composition

Invertebrates consisted 98.9% of all (N = 2855) prey items analysed by three different methods. Over 54% of these items were beetles; dung (Scarabaeidae) and ground (Carabidae) beetles accounted for almost one third of the prey. Hymenoptera, which is a diverse group consisting of ants (Formicidae), ichneumon flies (Ichneumonidae), bees (Apidae) and wasps (Vespidae), made up around 17% of all prey items identified. Grasshoppers, crickets (Orthoptera: Tettigonidae and Acridiidae) and bugs (Heteroptera) composited 16.3 and 6.4% of all prey items identified, respectively. Others invertebrate and vertebrates groups accounted together approximately 5.6%.

Variation between methods

Proportion of six prey taxa in Red-backed Shrike differ significantly between methods (G-test, G = 883.5, df = 2, $p < 0.00001$). The main findings show, that Coleoptera in pellets were over-represented, and Orthoptera in larders were over-represented (Fig. 1).

Literature comparisons

We reviewed the literature on feeding habits of the Red-backed Shrike in Europe. Studies selected for numerical analysis met the following criteria: 1) diet composition was estimated on the basis of well-defined method (three methods were

Table 1. Differences (mean ± SD) in the percentage (*arcsin* transformed before analyses) of numbers of five important insect groups in the diet of Red-backed Shrike. n — number of studies, F — results of ANOVA, p — probability. Sources of the data on diet composition: Arcas (1998), Cajander (1929), Daraktchiev & Germanov (1975), Hernandez (1995), Hernandez et al. (1993), Karg (2001), Korodi Gai (1969), Kuper et al. (2000), Lefranc (1979), Mann (1983, 1987), Mansfeld (1958), Mielewczyk (1967), Olsson (1995), Randik (1970), Skarzyńska (1956), Szlivka (1977), Wagner (1993).

Taxon	Collars (n = 11)	Pellets (n = 12)	Remains (n = 13)	F	p
Hymenoptera	9.2 ± 5.7	27.9 ± 17.5	17.3 ± 20.2	3.78	0.03
Coleoptera	37.0 ± 17.0	47.7 ± 14.6	43.2 ± 33.6	0.53	0.60
Orthoptera	9.4 ± 9.6	4.0 ± 5.3	14.0 ± 22.4	1.44	0.25
Diptera	12.1 ± 9.2	6.0 ± 3.4	1.3 ± 1.6	4.77	0.01
Lepidoptera	13.9 ± 10.4	0.3 ± 0.4	4.2 ± 1.9	11.23	0.00

taken into account: pellet analyses, collars and visiting the larders and food storage places); 2) food composition was based on the analysis of at least 50 prey items and expressed as the percentage of prey consumed. Investigations from 36 localities in Europe (this study included) met the criteria listed above (see Table 1). This analysis covered a large part of the geographical range of the Red-backed Shrike from southern Spain to Fennoscandia and from western France to eastern Slovakia.

In order to test for any differences in dietary composition, results obtained by using three different method of diet study, were compared (Table 1). Significant differences were found for the percentage of Hymenoptera, Diptera and Lepidoptera in the diet of the Red-backed Shrike (differences for Diptera and Lepidoptera were also significant at $p < 0.05$, when we used Bonferroni test for multiple comparisons).

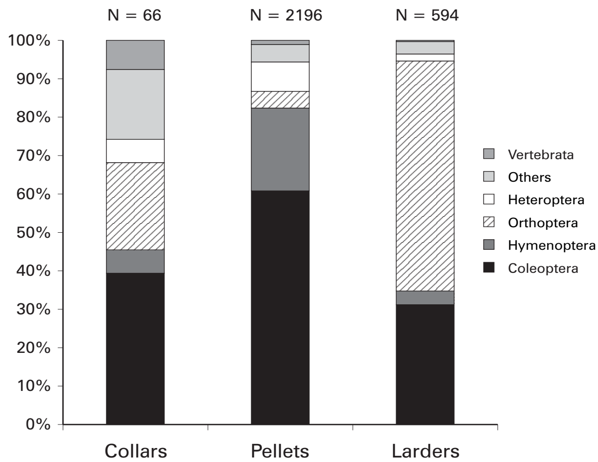

Fig. 1. Differences in the diet composition of the Red-backed Shrike in the present study determined by three different methods. N — sample size (number of prey items).

DISCUSSION

Diet composition

The composition of the Red-backed Shrike diet is influenced by many external factors including the foraging skills, habitat and territory quality, geographical location, weather conditions and time of day or season (Cramp & Perrins 1993, Hernandez et al. 1993, Leugger-Eggimann 1997). In general, results considered in this study give an adequate picture of Red-backed Shrike diet. This insectivore species, foraged mainly on large insects, such as of beetles, grasshoppers, bees and wasps. Its diet was supplemented by many other invertebrate taxa, as well as by small vertebrates (lizards, small mammals and small passerine birds). Such diet is similar to that in other studies, but the percentage of Coleoptera and Hymenoptera was higher (Table 1). It can be linked with higher density of these insects in Poland in comparison with west European countries (Lefranc 1997, Van Nieuwenhuyse et al. 1999). Hence, Polish population of the Red-Shrike is stable or even locally increasing (Kuźniak & Tryjanowski 2000, Kujawa 2002), while population in other European countries are declining (Lefranc 1997, Van Nieuwenhuyse et al. 1999).

Biases in the methods of diet analysis

Apart from the three most popular methods that were tested, other assessment of Red-backed

Shrike diet were also used: stomach analyses (many old papers, review in Cramp & Perrins 1993), faecal samples (Hernandez 1993), regurgitated food (Arcas 1998), food remains in the nests (Randik 1970, Olsson 1995), as well as indirect field observations (Favini et al. 1998, Hornman et al. 1998). However, these methods were used only in singular studies. Due to ethic reasons, methods such like stomach contents analysis from killed birds should not be applied. Of course, methods used produced different results on the diet composition, both in local, as well as in broader context (Rosenberg & Cooper 1990).

The main source of potential bias in methods, can result from differential digestibility of prey items. This could be an important factor limiting usefulness of the pellet analyses. Hence, there is a lower number of identified arthropods with soft body, e.g. flies or spider fragments (in this, as well as in many other studies). Second source of differences may result from the fact, that shrikes handle some bigger prey species (e.g. Coleoptera, Orthoptera, Vertebrata) before eating or, more often, before passing prey items to nestlings (Lefranc & Worfolk 1997). Although, Gwinner (1961) suggests that the Red-backed Shrike removes stings from bees and wasps before eating. We found stings not only in larders, but also in pellets (but not in collars). We suggest that larger difference exists in diet between age classes (nestlings vs. adults) rather than between method of diet assessment.

Collars are in general harmful to the nestlings (Rosenberg & Cooper 1990) and should be therefore used to provide information on presence or absence of certain prey items (especially Diptera and Lepidoptera) in diet which can be further quantified on a larger scale by some other method not harmful to nestlings.

In general, similar results as in our study were obtained by Olsson (1995 – Table 3), difference among these results were however not tested. Differences in assessing of diet contents by different methods are common in raptors (e.g. Simmons et al. 1991, Redpath et al. 2001), especially in small falcons, which have foraging biology similar to shrikes and with diet comprising insects and small vertebrates (e.g., Purger 1998).

It is difficult to determine, which method is the best fitted to safe and detailed studies of Red-backed Shrike diet. Results obtained by using different methods complement each other, and indication which one should be used depends mainly on the goals of studies.

The collars provide real data on nestlings' diet, but it is an invasive method. The use of other method is recommended, as directional observations from a hide (Hornman et al. 1998) and video-taping (Favini et al. 1998). However, these methods not always produced real picture, as identification of prey taxa is strongly limited. Moreover, as in collars study and in direct field observations, the presence of observer near shrike nest can negatively influence breeding success of the Red-backed Shrike (Tryjanowski & Kuźniak 1999). It is therefore better to use non-invasive method like pellet analysis and larder searching (or both), if you keep in mind that both methods produce bias and are limited.

Conclusions

Our findings suggest that pellet analyses are easy and non-invasive method for estimates of prey diversity and frequency index, but collars may be necessary to establish nestling diets, and prey remains in larders to find large prey, handled before eating. To determine diet composition and predict impact of food sources on local populations, all three methods should be used simultaneously. Similarly, in more advanced geographical and/or habitat gradients analysis of shrike diet content, we are recommend to pool data together obtained by different method techniques in the same place, and/or (better) carefully assessing methods of diet analysis.

ACKNOWLEDGEMENTS

We thank M. Hromada, M. Antczak, S. Karlsson, A. Surmacki, V. Takacs and especially G. Kopij for their comments on the early draft of this paper. We were partially supported by GEF/SGP, UAM and KBN (6 P0 4F 046 21) grants.

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STRESZCZENIE

[Badania składu pokarmu gąsiorka: porównanie wyników uzyskanych metodami analizy pierścieni okołoszyjnych, wypluwek i resztek pokarmowych]

Gąsiorek jest gatunkiem, u którego dokładnie opisano zarówno skład diety, jak i techniki żerowania. Gąsiorek jest generalnie owadożerny, choć czasami uzupełnia dietę o drobne kręgowce. Skład jego diety podlega silnym zmianom w zależności od lokalizacji geograficznej, siedliska, czy okresu badań. Dotychczas jednak nie zwracano uwagi, że część opisywanej zmienności w składzie diety tego gatunku może być prostą konsekwencją stosowania różnych metod badawczych.

Głównym celem pracy było zbadanie różnic pomiędzy trzema najczęściej stosowanymi metodami ustalania składu pokarmu gąsiorka: analizy pierścieni okołoszyjnych, wypluwek i resztek pokarmowych.

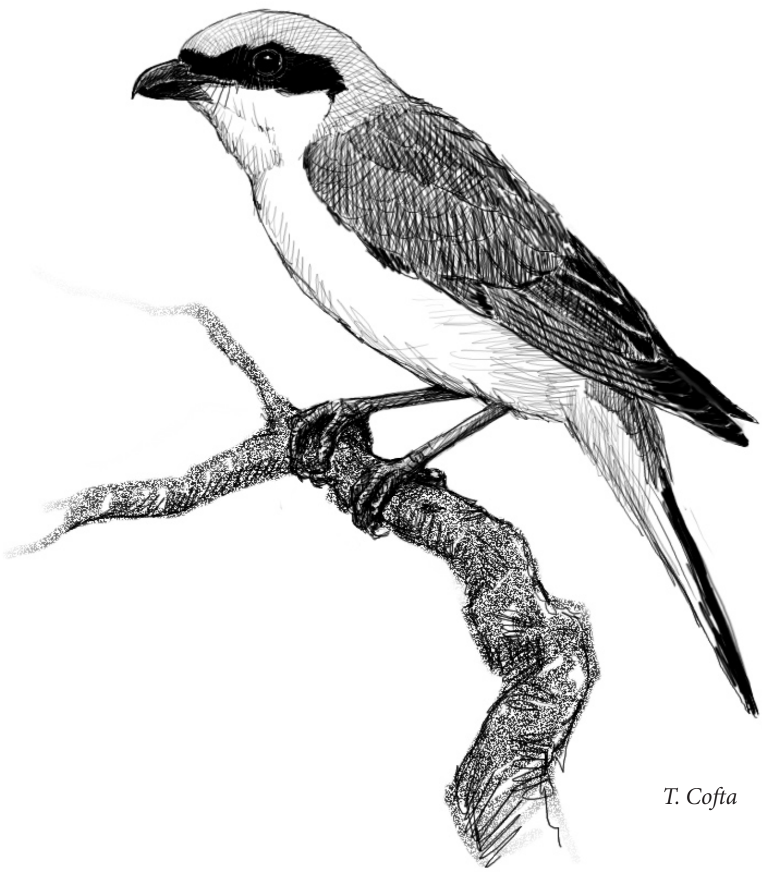
Dane o składzie pokarmu przy użyciu trzech wymienionych metod stosowano na tym samym terenie, w okolicach Turwi (Wielkopolska). Na podstawie 2855 zidentyfikowanych ofiar (z wszystkich trzech metod łącznie) ustalono, że

trzy grupy owadów (Coleoptera, Hymenoptera i Orthoptera) stanowią łącznie 98.9% wszystkich ofiar gąsiorka.

Jednak okazało się, że stosowane metody dają bardzo zróżnicowany obraz diety tego gatunku (Fig. 1, Tab. 1). Proporcje spożywanych ofiar ustalanych na bazie różnych metod różnią się istotnie statystycznie. Podstawowe różnice to nadreprezentacja Coleoptera w analizie wypluwkowej i podobnie zawyżona liczebność Orthoptera w analizie resztek pokarmowych. Jest to konsekwencja dobrego zachowywania się twardych części chrząszczy w wypluwkach, i wielkości owadów prostoskrzydłych, które są przed spożyciem przygotowywane w tzw. rzeźniach, gdzie dobrze zachowują się ich szczątki (skrzydła i odwłoki).

Dodatkowo uzyskane wyniki zinterpretowano w szerszym kontekście badań nad dietą gąsiorka w Europie. W tym celu dokonano przeglądu literatury dotyczącej składu pokarmu tego gatunku (dane w Tab. 1). Wykonane analizy (Tab. 1) wyraźnie wskazują, że wyniki badań poza czynnikami naturalnymi (np. położenie geograficzne, siedlisko) mogą być konsekwencją zastosowanych metod badawczych. Różnice dotyczą przede wszystkim ofiar, które słabo zachowują się w materiale wypluwkowym — Hymenoptera, Diptera i Lepidoptera. Ponadto, ze względu na wielkość, są one relatywnie rzadziej przez dzierzby specjalnie przygotowywane przed spożyciem, i stąd ich nikła obecność w rzeźniach.

Metodą optymalną mającą zobrazować skład diety lokalnych populacji gąsiorka, jest łączne stosowanie wszystkich metod. Natomiast w przypadku podejmowania szerzej zakrojonych analiz (np. nad geograficznym zróżnicowaniem składu pokarmu) niezbędna jest (statystyczna) kontrola różnic będących pochodną stosowanych technik badawczych.



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