First description of red-backed shrike *Lanius collurio* food caching in Central Italy: prey's type and spatial position into the larders

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Abstract – The food storage and the use of impaling or wedging the preys in larders is a typical behaviour of true shrikes. In this study we present the preliminary results about this behaviour of red-backed shrikes in Central Italy, where this behaviour was rarely recorded. We focused on the larders description, prey composition and spatial pattern of prey fixation in the larder. Our results are the first data about this particular behaviour in Italy since 1933 and highlighted the importance that it could have also as signalling function of territoriality. Our results showed that the main vegetal support used was *Prunus spinosa L.*, used also for impale the heavier prey (micromammals, reptiles and birds). The invertebrate constituted 78% of items in the larders, with vertebrate prey in the rest. The height from ground where prey is impaled was correlated with shrub height, but the concealment level was independent from prey type.

Key-words: impaling, food store, shrub, breeding, farmland.

INTRODUCTION

The behavior of food storing is aimed at the deposition of food items in a particular location for later consumption. It has been observed in a number of bird and mammal species (Smith 1973, Roberts 1979, Smith & Reichman 1984, Vander Wall & Peterson 1996). Short-term food storage is known primarily in shrikes and birds of prey (Smith 1972, Newton 1979, Walter 1979) and in some cracticids, parids and corvids (Pizzey 1980, Smith & Reichman 1984). Among the birds, the most conspicuous case of this behavior is perhaps that of the some Laniidae species (Donovan 1929, Applegate 1977, Yosef & Pinshow 2005). In Europe the impaling of prey is a behavioral trait restricted only to the different shrikes species (Kristín *et al*. 2004, Yosef & Pinshow 2005). The shrikes are small to medium-sized passerines that show some similarities to raptors both in morphology and mainly in lifestyle, e.g. hunting techniques (Cade 1995). However, shrikes, unlike raptors, do not have talons or strong feet, and thus they do not use legs during manipulation of prey, but they usually impale and wedge prey for dismembering large prey and dividing them into parts in a following time. This particular behaviour is considered as an evolutionary feeding adaptation, and a tool that facilitates the dismemberment of prey at lower energetic costs to the predator (Whyte 1887, Yao 1985, Olsson 1986, Schon 1994, Cade 1995).

Food wedging and caching in shrikes provides also important benefits during harsh weather conditions (Lefranc & Worfolk 1997, Tryjanowski & Golawski 2004), or when energy requirements increase rapidly, for example during egg laying and rapid growth of nestlings (Carlson 1985). This behavior could play also an important informative role, as a signal of good quality of the territory or of the territory-owner: in fact, the impaled objects located in conspicuous places might serve as landmarks for territory demarcation (Sloane 1991) allowing improve the owner's breeding success, as shown by Yosef & Pinshow (1989).

Current bibliography does not report examples of impaling behavior of red-backed shrike *Lanius collurio* in Italy. Some authors have reported even that cases of food storage in the larders are rarely reported in the whole Italian peninsula (Moltoni 1933, Brambilla *et al*. 2007, Casale & Brambilla 2009).

Here we present the first documented observations and description of this behavior in Central Italy, where red-

backed shrike breeds mainly in farmland landscapes (Morelli & Pandolfi 2011, Morelli *et al*. 2012, Morelli 2012). We also describe the shrub species used for food storage, the spatial distribution of prey items in the larders and the species mainly captured as prey.

MATERIALS AND METHODS

This study was carried out in Central-eastern Italy, on the foothills of the Apennines, landscape of mosaic of agricultural areas, with few woodland patches and scattered shrubs and hedges, in the Northern Marche region (43°49.270'N, 12°26.800'E) (Fig. 1), at an altitude ranging between 0 and 700 m a.s.l. The climate in Central Italy is temperate (Tomaselli *et al*. 1972), and is characterized by high spring and summer temperatures and a marked summer drought. From mid-April to mid-June 2011, an area well-known for breeding of red-backed shrike was visited using a constant sampling effort (days for search) in order to cover as uniform as possible the entire area (Bibby *et al*. 1997). We recorded all contacts with territoriality activities by direct observation of individuals during arrival, courtship and nest-building (Brambilla *et al*. 2007). The occupied territories were surveyed every three days during the initial phase of breeding period in order to locate the larders, because mating and incubation seem to be the periods most suitable for detecting fixed prey, due to the minor hidden level and lower food consumption (Antczak *et al*. 2005). Inspections were carried out on all shrubs focusing in particular the most frequent activities of both males and females (prey transport and territorial behavior) with the aim of detecting the fixed prey. Some caching and capture of prey were observed directly. Each larder was considered as a single unit of study to be characterized, when it was attributed to a particular breeding pair.

Figure 1. Geographic location of the study area (Marche region, Central Italy).

Larders description

In order to describe the larder and the environmental variables around this, were recorded the following parameters: altitude, m a.s.l.; percentage of land-use cover in the 100 m around the larder; support type of the fixed prey: plant, barbed wire, etc.; plant species, height, length (long axis) width (m) and shape from above: circular, rectangular or irregular; exposure of larder: N, S, W, E; landscape in the direction of exposure (land use); possible use of shrub as a perch: (by direct observations or indirect signals); road type (paved and unpaved) and distance to the nearest (m).

Prey types and spatial patterns of prey items fixation

We recorded the following parameters: prey species and category (insect: 1, reptile: 2, bird: 3, mammal: 4); prey number for larder, and eventually distance between prey; prey height from the ground (m); fixation types (impaled or wedged); concealment (prey hidden in the shrub foliage in relation to the coverage level, as high, medium or low).

In order to establish the spatial distribution of the prey items, their position on shrub was divided into two zones: frontal position (seeing the prey in relation to a frontal position, considering the shrub as a circle with the base on ground and the high margin of circle in the highest portion of the shrub, we indicated the prey position into the scheme of the Fig. 2, recording the angle as a circular distribution from the zero in the circle) and depth position (depth of the prey in the foliage, using the following codes: inner, medium, outer).

Statistical analysis

Data are presented as mean values ± SE. Correlation between prey height and several studied parameters, and between level of concealment and prey categories were analyzed by mean of Spearman correlation test. Differences in the spatial position of fixed prey items were compared using χ^2 tests. Furthermore, to explore the prey disposition in the frontal position of the larder, we used the approach of circular stats, using a rose diagram representation and Rayleigh test (Zar 1974) to verify differences in the place of fixation in terms of angle of the radial position. Circular statistics are useful when trying to analyze data that are taken from a distribution that circles back on itself. For instance, consider the circular and linear distributions of 360 equidistant points. In the linear distribution 0 and 360 are at opposite ends of the distribution, whereas in the circular distribution the points 0 and 360 are one and the same. The

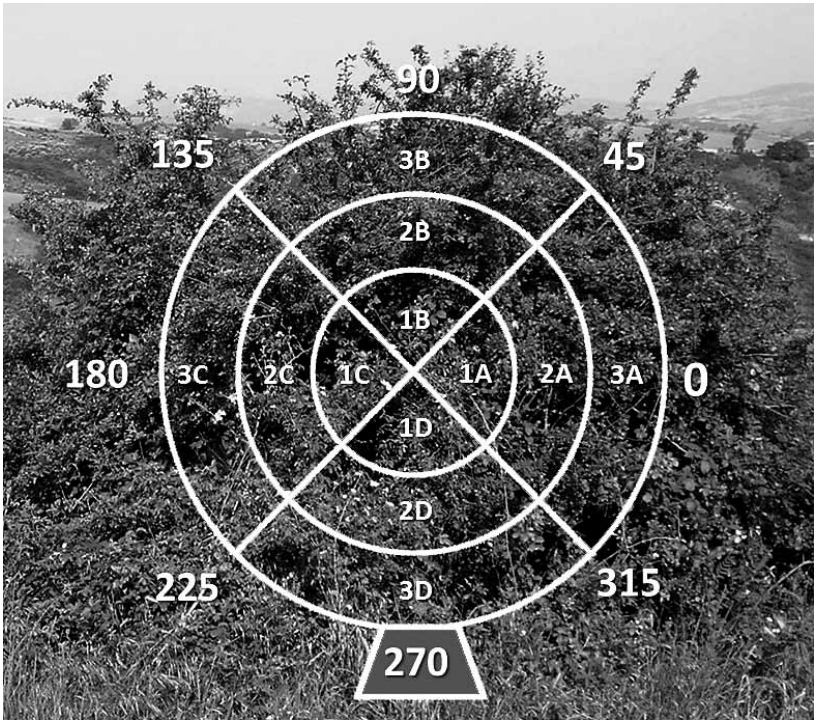

Figure 2. Scheme of prey item fixation in the frontal position of shrubs.

angular values were measured respect to an arbitrary zero positioned in half of the right side and were transformed in radians.

All tests and elaborations were performed with R program (R Development Core Team 2011).

RESULTS

A total of 37 larders of red-backed shrike were studied during the first year in farmland of Central Italy. Both types of larders were found: with only a single prey (35) and (less frequently) with more than one prey (2 cases with 2 different prey). The only two larders with more number of prey items were characterized by the presence of Hymenoptera species, on *Prunus spinosa* shrub, and the minimum distance between prey was 0.6 m meanwhile the maximum distance was almost 3 m.

Larders description

The larders were ranged from a minimum of 105 m of altitude to a maximum of 529 m, with a mean value of 319.8 ± 150.1 m (a.s.l.). The land-use composition around the larders is showed in the Tab. 1. All the stored prey items that have been detected in the present study were placed on a natural support (plants). Larders on barbed wire or other artificial structures were not observed. The most used shrub species was *Prunus spinosa* (Tab. 3), having a shape from above mainly rectangular or circular, and a mean

Table 1. Landscape around the larders and plants measures.

PARAMETERS	Mean	SD	Min	Max
Land use level (%)				
Cultivated	44.8	16.4	20	80
Hedgerows	7.7	10.5	5	30
Trees dispersal	2.8	5.9	0	20
Uncultivated	7.5	14.2	5	40
Badlands	0.5	1.5	0	5
Shrubs	20.5	10.1	5	30
Urban	0.8	2.6	0	10
Grassland	6.2	16.7	0	60
Forest	3.2	7.0	0	30
Vineyard	6.0	13.8	0	40
Road distance (m)	31.1	63.4	0.3	290
Support level (m)				
Plant height	2.5	1.2	1	6
Plant length	6.3	5.2	1.1	25
Plant width	3.4	1.7	0.9	10

Table 2. Prey composition in the larders of red-backed shrike in Central Italy.

PREY ITEMS	n	%
Invertebrata		
LEPIDOPTERA		
Saturnia pyri (larva)	3	12.0
Vanessa cardui	1	4.0
Zygaena filipendulae	1	4.0
COLEOPTERA		
Capnodis tenebrionis	1	4.0
Feronia nigrita	3	12.0
Rhizotrogini sp.	2	8.0
HYMENOPTERA		
Bombus sp	9	36.0
Apoidea sp	3	12.0
RHYNCHOTA		
Lygaeus saxatilis	2	8.0
ORTHOPTERA		
Sepiana sepium	4	16.0
Mantodea	2	8.0
Invertebrata subtotal	**31**	**77.5**
Vertebrata		
REPTILIA		
Hierophis viridiflavus	1	11.1
Podarcis muralis	2	22.2
Lacerta viridis	2	22.2
AVES		
Sylvia atricapilla	1	11.1
Serinus serinus	1	11.1
MAMMALIA		
Sorex araneus	1	11.1
Apodemus sylvaticus	1	11.1
Vertebrata subtotal	**9**	**22.5**

height of 2.5 ± 1.2 m (Tab. 1). The exposures of larders were: W (30%), NW (26%), N (17%) and NE (13%). The main landscape typologies from the larder exposure were: paved roads (38%) and cultivated (31%). The shrubs used as larder were used usually also as perches.

Prey types and spatial patterns of prey items fixation

A total of 40 prey items were identified, belonging to 18 taxa (Tab. 2). The proportion of vertebrates and invertebrates in our preliminary results was 22% and 78% respectively. The most common prey types were species of Hymenoptera, Lepidoptera and Coleoptera. We found prey items of vertebrates belonging to three different classes: Reptilia (5 items), Aves (2 items) and Mammalia (2 items). The prey items were positioned mainly at 1.33 ± 0.4 m (range 1.9-0.4 m) from the ground. Prey height was correlated with plant height (Spearman correlation $r = 0.41$, $n = 40$, $P = 0.01$) and was not significantly correlated with prey categories and road distance ($P > 0.05$) (Fig. 3).

We record two types of fixation used to place items in the larder: impaled (95%) and wedged (5%). The only wedged items were one *Saturnia pyri* larva and one Hymenoptera Apoidea; they were supported in the fork of two branches.

The level of concealment prey fixed in the larder in relation to the foliage coverage was not correlated with prey categories (Spearman correlation $P > 0.05$). The 57% of prey items were found without foliage coverage, at low level of concealment. The spatial distribution of the prey items in the shrub show that preys were not uniformly distributed around the circle and the most used part was the central area in frontal position (Rayleigh's test $z = 4.25$, $N = 40$, $P < 0.05$; Fig. 4), mainly in A2, C2, D1 and D2 (Chi-square = 24.5, df = 5, p-value = 0.0001) (see in Fig. 2 the scheme of frontal position). The prey items were found mainly in the outer (60.0%) and medium position (37.5%) in relation to depth in the foliage of the shrub, with only one case of fixation into the inner position (2.5%) (prey item: *Apodemus sylvaticus*).

Table 3. Prey items stored in the different shrub species.

VEGETAL SPECIES	Total items	Percentage %	Lepidoptera	Coleoptera	Hymenoptera	Rhynchota	Orthoptera	Reptilia	Mammalia	Aves
Prunus domestica L.	1	2.5	-	-	1	-	-	-	-	-
Prunus spinosa L.	31	77.5	3	4	9	2	4	5	2	2
Rosa canina L.	4	10	2	-	-	-	2	-	-	-
Rubus ulmifolius Schott	4	10	-	2	2	-	-	-	-	-

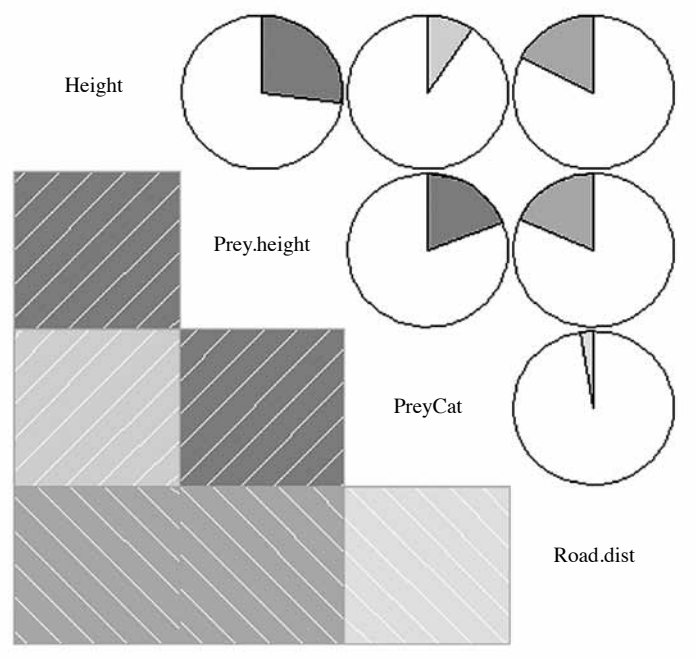

Figure 3. Correlation analysis between prey height from ground (height) and plant height, prey category and road distance (dark colour indicates positive if in the right half of circle, negative values of correlation if in the left half of circle).

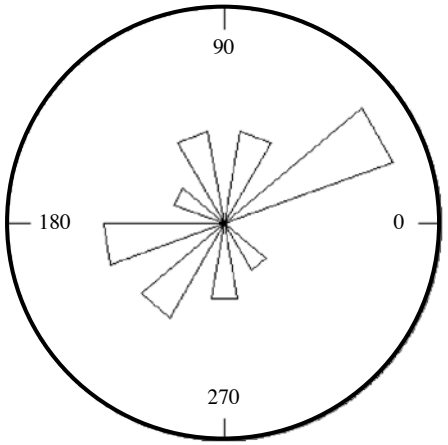

Figure 4. Rose diagram representing the pattern of prey items fixed in the frontal position of shrub (the area of the sectors are proportional to the observation frequency per group).

DISCUSSION

In shrikes, is generally the male to impale the prey, whereas this behaviour is rarer in females and young (Harris & Franklin 2000). During the mating period they impale more prey before mating than after, and the majority of prey are located on the borders of individual territories, in visible places, where are left uneaten. Indeed, in some studies, males were observed to impale inedible objects such as rags, snail and eggshells, fecal sacs or even bread crusts, ostensibly to boost the visual effect of the cache (Durango 1956, Lorenz & St. Paul 1968, Leonard 1992). This pattern indicates how during the mating period impaling behavior has a signaling function of territoriality.

Our preliminary results constitute one of the first description about the use of larders by red-backed shrike in Italy (Moltoni 1933, Casale & Brambilla 2009), showing a rich prey composition, belonging to 18 different taxa in only 31 studied larders according to the well-known foraging characteristics of the species, which can be defined as an opportunistic hunter (Harris & Franklin 2000). The proportion of vertebrates and invertebrates was similar to that reported in previous European studies for other shrikes (Olsson 1986, Tryjanowski *et al*. 2003, Nikolov *et al*. 2004). The composition of cached prey was dominated by insects (mainly bumble bees, beetles and grasshoppers) in terms of numbers, and by birds, snakes and lizards in terms of biomass.

The record of *Zygaena filipendulae* among the prey items, a very coloured but toxic butterfly containing cyanogenic glucosides (Zagrobelny *et al*. 2007), highlights the role of larders also in territoriality displays of red-backed shrike. The use of conspicuous impaled prey allows also to communicate with conspecifics; in some cases the use

Figure 5. Impaled prey of red-backed shrikes in Central Italy (a: *Mantodea*; b: *Serinus serinus*; c: *Sorex araneus*; d: *Zygaena filipendulae*; e: *Hierophis viridiflavus*; f: *Lacerta viridis*; g: *Sepiana sepium*).

of coloured prey could constitute parameters for sexual selection, in order to attract the female or to signal to other males that the territory is occupied (Yosef & Pinshow 1989, 2005).

Larders were located on natural supports, mainly large and dense shrubs. We believe that larders were not observed on the barbed wire because in the study areas thorn shrubs are highly available. The most used shrub species was *Prunus spinosa*, characterized by the strong thorns, very suitable to impale the prey. Furthermore *Prunus spinosa* was the only vegetal support that was used to fix all the prey types, used also for impale the heaviest prey (micromammals, reptiles and birds).

Our results showed that the red-backed shrike positioned the prey at mean heights, that correspond with the middle parts of the plants. Indeed we verified a positive correlation between prey height and shrub height, result that coincides with other studies on shrikes (Nikolov *et al*. 2004). Our preliminary results not found a correlation between prey categories and fixation position on the shrub or concealment level. However, carrying on observations later in the breeding season would be interesting for comparison, because larders become more important as storing food (Antczak *et al*. 2005) and thus prey may be better hidden. Carlson (1985) has suggested that selected larders sites of red-backed shrike follow a compromise between maximizing the rate of food delivery to the offspring and minimizing both the risk of kleptoparasitism and the location of nest by potential predators.

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