


Nesting ecology of Lesser Grey and Woodchat Shrikes in Apulia, southern Italy

GIANPASQUALE CHIATANTE^{1*}

¹ Department of Earth and Environmental Sciences, University of Pavia, Via A. Ferrata 1, 27100 Pavia, Italy

* corresponding author: gp.chiatante@gmail.com

 0000-0002-4570-9350

Abstract - True shrikes (family Laniidae, genus *Lanius*) are birds highly associated with open and farmed landscapes and have suffered significant declines all over the world, especially due to increasingly intense agriculture and climatic fluctuations. In Italy, three species breed: Red-backed Shrike (*Lanius collurio*), Lesser Grey Shrike (*Lanius minor*) and Woodchat Shrike (*Lanius senator*). All three are threatened and considered Vulnerable (the first two species) or Endangered (the latter species) in Italy. The purpose of this study was to provide new insights on the nesting ecology of Lesser Grey and Woodchat Shrikes in Italy by territory mapping in six sampling areas in Apulia in 2009-2013. I also collected data on nest location and breeding success. I mapped 93 territories of Lesser Grey Shrike (for 127 breeding attempts) and 84 territories of Woodchat Shrike (for 107 breeding attempts) and noted a decline in shrike numbers over the five years. Most territories of Lesser Grey Shrikes were used for one nesting attempt (71.0%) and the remainder used twice, showing a clear site fidelity. Similarly for the Woodchat Shrike, more than 20% of territories were used for two nesting attempts. Both species formed solitary pairs, but 5% of Lesser Grey Shrike formed two-pair clusters and I found only a single two-pair cluster of Woodchat Shrikes. Lesser Grey Shrikes nested in isolated trees (mainly oaks, elms, almond, and olive trees), building a nest at 4.2 m above the ground, partially hidden and placed in a distal position respect the tree trunk. The first record of Macedonian Oak and Olive being used for nest support was obtained. I found only three nests of the Woodchat Shrike. Fledged broods of Lesser Grey Shrike composed on average 2.3 juveniles; for the Woodchat Shrike this value is 1.9 juveniles.

Key words: *Lanius*, shrikes, steppe birds, farmland birds, Mediterranean Basin

INTRODUCTION

True shrikes (family Laniidae, genus *Lanius*) are birds highly associated with open and farmed landscapes and as a result have suffered significant declines in their numbers and distribution (Yosef 1994, Yosef & Lohrer 1995). The main causes of decline are ascribed to (a) increasingly intensive agriculture that alters landscapes, removes hedgerows, and

makes heavy use of fertilizers and pesticides (Yosef & Deyrup 1998), and (b) climatic fluctuations both in the breeding and in the wintering quarters (Lefranc & Worfolk 1997, Panov 2011). In Italy three species breed: the Red-backed Shrike (*Lanius collurio*) (20,000-60,000 pairs), the Lesser Grey Shrike (*Lanius minor*) (1000-2000 pairs), and the Woodchat Shrike (*Lanius senator*) (4000 pairs) (BirdLife International

2017). All three species are threatened, indeed the first two are considered Vulnerable whereas the latter is Endangered (Rondinini et al. 2013); in addition the Red-backed and the Lesser Grey Shrike are listed in the Annex I of the Birds Directive (2009/147/EC). The aim of this research is to provide new insights concerning the nesting ecology of Lesser Grey and Woodchat shrikes in Italy using data collected in Apulia, in southern Italy, between 2009 and 2013. Generally, the Lesser Grey Shrike inhabits open areas with small woods and scattered trees and is strongly associated with traditional agricultural landscapes (Cramp & Perrins 1993, Lefranc & Worfolk 1997, Panov 2011). The Woodchat Shrike is mainly associated with Mediterranean areas where it breeds in grasslands with shrubs and scattered trees, arid steppes, and semi-deserts. However, it breeds also in plantations, especially olive groves and traditional orchards (Cramp & Perrins 1993, Lefranc & Worfolk 1997, Panov 2011). Past research in the region showed that both species occur in areas with natural grasslands and non-irrigated cereal crops, with scattered trees and shrubs, even though the Woodchat Shrike is associated to areas with more shrubs (Chiatante et al. 2014, Chiatante 2019). Moreover, the strong overlap in their habitat niches suggests heterospecific social attraction between them; particularly, the Lesser Grey Shrike may use occurrences of the Woodchat Shrike as a cue for assessing habitat quality and establish its territory (Chiatante 2019).

MATERIALS AND METHODS

Study area

The study included the whole Apulia region in south-eastern Italy (19,358 km²) (Fig. 1). The area is dominated by lowland plains with hills and small mountains in the northern portion of the region (highest peak 1151 m a.s.l.). The landscape is composed of non-irrigated cereal crops (42.4%), olive groves (24.2%), vineyards (7.5%), natural grasslands (5.6%), and deciduous woodlands (5.4%). In this present study, six sampling areas

comprising 7636 km² were checked (Electronic Supplementary Materials, ESM Tab. 1). Climate is typically Mediterranean: the summers are warm, windy, and dry, whilst the winters are mild and rainy. Temperatures vary between 2–13° C in January–February and 16–30° C in July–August; precipitation occurs mainly during the late autumn and winter (average rainfall between 27–28 mm in July and 67 mm in October).

Fieldwork

Between 1 June and 31 July in 2009–2013, I censused the two shrike species through territory mapping (Bibby et al. 2000) by making roadside surveys using the car transect method (Smith & Kruse 1992, Froehly et al. 2019), carrying out seven transects at low speed (20–40 km/h) and avoiding medium and high traffic roads. Transect average length was 156 km and total coverage was 1083 km (Fig. 1). Sampling areas were surveyed at least two and up to five times with the number of visits dictated by the area, terrain, and number of previous contacts with the target species. Using this method, pairs were located and the territory boundaries were defined by the observation of breeding behaviours, such as courtship, copulation, nest building, and nestling rearing. This technique has been used elsewhere with other *Lanius* species and takes advantage of their highly territorial and conspicuous behaviour (Brambilla et al. 2009, Ceresa et al. 2012, Chiatante et al. 2014). In 2009–2010, I searched also nests of the two species by observing the behaviour of birds in their territories. Since shrikes are very sensitive to being disturbed at the nest (Tryjanowski & Kuźniak 1999, Panov 2011), when a nest was found I did not look inside to avoid causing desertion and therefore I do not have information on eggs or chicks in the nest. However, at the end of the season, I collected data about the nest: species of shrub/trees in which the nest was built, its isolation, height, and crown diameter. Isolation was defined based on three levels: (i) isolated shrub or tree, (ii) hedgerow of shrubs or trees and (iii) group of shrubs or trees (e.g.

orchards) (see ESM Fig. 1 for some examples). Nest tree height was calculated through trigonometric principles (van Laar & Akça 2007) after I measured distance from eye level to tree crown and to tree top by a laser rangefinder (Leica Rangemaster 900; Leica, Solms, Germany), whereas crown diameters were measured with a tape. For nests, I measured its height above the ground, its concealment (three levels: visible/partially hidden/hidden, by observing the nest support from a distance of 2 m; Isenmann & Fradet 1998) and its horizontal (proximal/distal) and vertical (bottom/centre/top) placement in relation to the barycentre of the crown. Finally, since juvenile shrikes have conspicuous behaviour because of their unmistakable begging call (Cramp & Perrins 1993, Lefranc & Worfolk 1997), I collected data concerning

the families, in particular noting the number of juveniles fledged per pair, which was used as a measure of productivity.

Analyses

The data were statistically analysed by standard non-parametric methods (Legendre & Legendre 1998). Considering that five years are few for a complex time series analysis, the number of territories recorded along the transects was tested for a linear relation with years (2009-2013) using the Spearman's rank correlation (Legendre & Legendre 1998). I assigned territories found in the same year to a cluster when distances between them were lesser than 150 m (Wirtitsch et al. 2001), otherwise they were considered as solitary pairs. Moreover, I

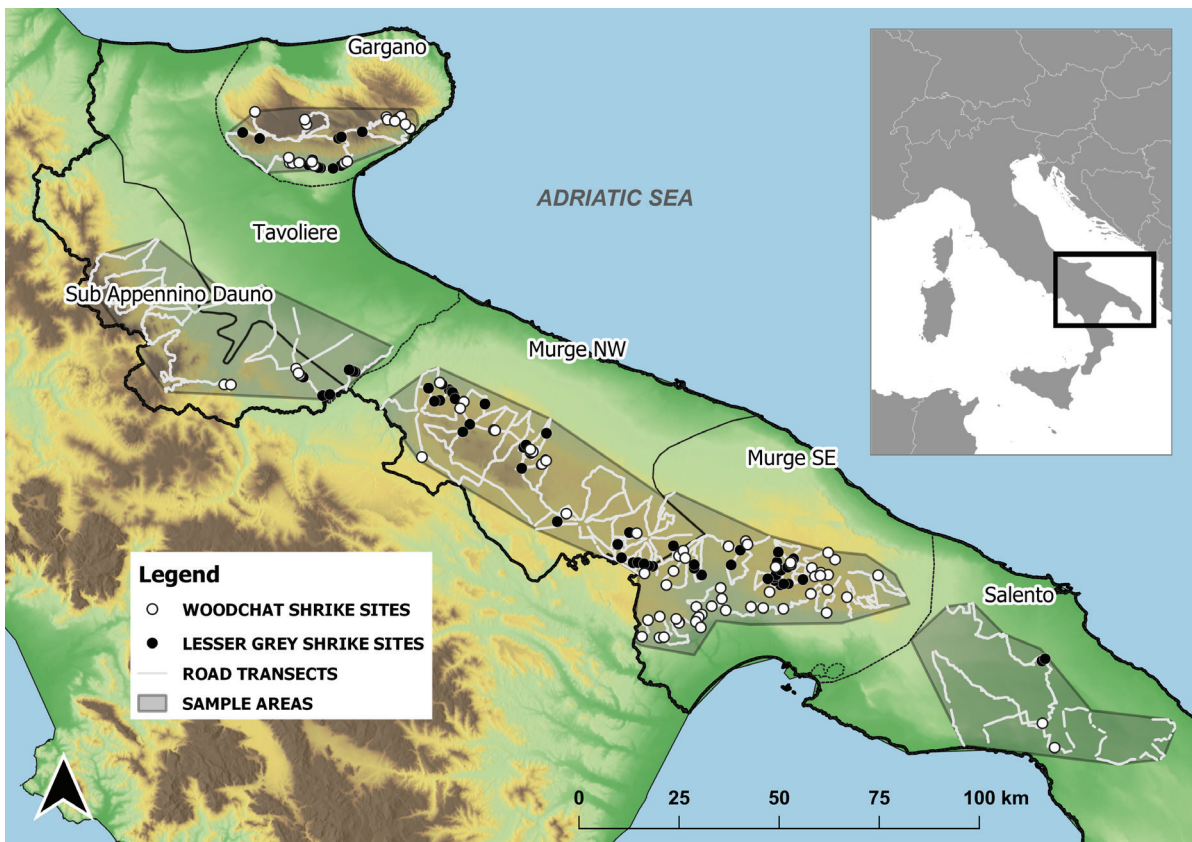


Figure 1. The areas sampled between 2009 and 2013 in Apulia. Black dots represent Lesser Grey Shrike territories, white dots Woodchat Shrike territories.

assessed territory fidelity between years assuming birds present had returned to their same territory if nests were within 100 m of the previous year's nest (Krištín et al. 2007, Hoi et al. 2012). Therefore, all sites found beyond 100 m in subsequent years were defined as new sites. In addition to variables collected during the fieldwork for the nests, I measured also the distance to the nearest building, identifying also if inhabited or uninhabited, and to the nearest paved or unpaved road. These distances, however, could be not representative of the species habits because these data were collected along roads. All the statistical analyses were carried out by R v.3.6.1 (R Core Team 2019) and the spatial analyses, including distance measurements, by the software QGIS v.3.8.3 "Zanzibar".

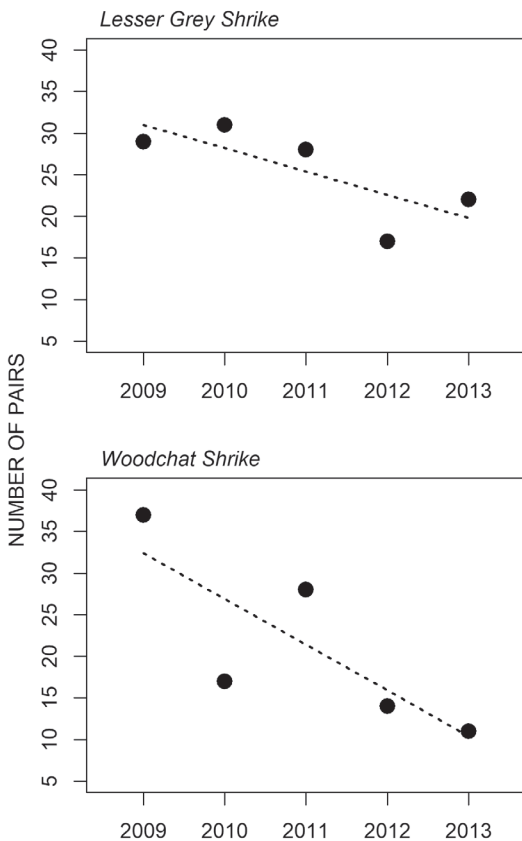


Figure 2. The number of territories of Lesser Grey Shrike and Woodchat Shrike found in Apulia (southern Italy) in 2009-2013 with territory mapping.

RESULTS

Lesser Grey Shrike

I mapped 93 territories (Fig. 1) representing 127 breeding attempts distributed as 29 in 2009, 31 in 2010, 28 in 2011, 17 in 2012, and 22 in 2013, representing a non-statistically significant decline in numbers ($r_s = -0.80, P = 0.133$) (Fig. 2). Most territories were used only once (N = 66, 71.0%), 21 (22.6%) were used twice (nine used in two consecutive years and 12 in non-consecutive years), and five territories (5.4%) were used three times (two in consecutive years, three in non-consecutive years), and one territory (1.0%) was occupied for four years. Minimum distance between territories was 47 m, with an average equal to $332 \text{ m} \pm 279$ (SD). The species has nested in solitary pairs (121 territories, 95.3%) or in clusters of 2 pairs (3 colonies, 4.7%). Minimum distance to a territory of Woodchat Shrike was 36 m, with an average equal to $132 \text{ m} \pm 186$ (SD). There were 7 instances of Lesser Grey Shrikes associating with Woodchat Shrikes which involved mainly solitary pairs (N = 6, 85.7%) and one case of a two-pair cluster. One solitary pair of Lesser Grey Shrikes nested in association with a two-pair cluster of Woodchat Shrikes.

I found 26 nests (see Tab. 1 for a summary) which were built on trees (84.6%) or shrubs (15.4%) and were generally isolated (65.4%). In particular, 19.2% were built on Macedonian Oaks (*Quercus trojana*), 11.5% on Downy Oaks (*Quercus pubescens*), and 11.5% on Elms (*Ulmus* sp.). Almonds (*Prunus dulcis*) and Olives (*Olea europea*) were equally used (both 15.4%) by the species in orchards. Other trees used (3.8%) were Black Poplar (*Populus nigra*), Plane (*Platanus* sp.), and Black Locust (*Robinia pseudoacacia*). Almond-leaved Pear (*Pyrus amygdaliformis*) were the only shrub in which I found nests (15.4%). In two cases, shrikes used an old nest of the Eurasian Magpie (*Pica pica*) placed on Macedonian and Downy Oaks respectively. The nests were built at an average height of 4.2 m (N = 19, SD = 1.6 m) with a positive correlation between the height above the ground and the height of tree/shrub ($r_s = 0.943$). Most nests were partially hidden

Table 1. Summary of the characteristics of the nests of Lesser Grey Shrike (N = 26) and Woodchat Shrike (N = 3) found in pulia during 2009-2013.

	Lesser Grey Shrike	Woodchat Shrike
Isolation of tree/shrub	Isolated 65.4%	Isolated 100.0%
	Hedgerow 7.7%	Hedgerow 0.0%
	Group 26.9%	Group 0.0%
Height of tree/shrub (m)	5.4 ± 2.1 (mean ± SD)	4.7 ± 1.8 (mean ± SD)
	2.5 – 10 (min – max)	3.5 – 6.8 (min – max)
Diameter of tree/shrub crown (m)	6.0 ± 4.4 (mean ± SD)	4.5 ± 0.7 (mean ± SD)
	2.0 – 23.3 (min – max)	3.6 – 4.8 (min – max)
Height above the ground (m)	4.2 ± 1.6 (mean ± SD)	3.3 ± 0.5 (mean ± SD)
	2.0 – 8.5 (min – max)	2.8 – 3.8 (min – max)
Nest concealment	Visible 19.0%	Visible 0.0%
	Partially hidden 62.0%	Partially hidden 66.6%
	Hidden 19.0%	Hidden 33.3%
Horizontal placement	Proximal 36.8%	Proximal 66.6%
	Distal 63.2%	Distal 33.3%
Vertical placement	Top 52.6%	Top 33.3%
	Centre 47.4%	Centre 66.6%
	Bottom 0.0%	Bottom 0.0%
Distance from buildings (m)	257.7 ± 182.5 (mean ± D)	178.0 ± 162.4 (mean ± D)
	55.0 – 651.6 (min – max)	38.7 – 356.4 (min – max)
Building type	Inhabited 61.5%	Inhabited 33.3%
	Uninhabited 38.5%	Uninhabited 66.6%
Distance from roads (m)	35.0 ± 30.4 (mean ± SD)	30.0 ± 20.6 (mean ± SD)
	0 – 109.1 (min – max)	6.4 – 44.0 (min – max)
Road type	Paved 96.2%	Paved 66.6%
	Unpaved 3.8%	Unpaved 33.3%

(62.0%), most of them (12 of 19) were located distally on horizontal branches and seven had a more proximal location; there were no evidence that this species selects a specific vertical placement. Average distance to buildings was 258 m; average distance to roads was 35 m. I found 32 families of Lesser Grey Shrike, composed on average of 2.25 juveniles \pm 1.02 (SD). The distribution of juveniles was quite equal among families, indeed nine had one juvenile (28.1%), 10 had two (31.3%), and nine had three juveniles (28.1%); four pairs (12.5%) reared four juveniles.

Woodchat Shrike

I mapped 84 territories (Fig. 1) representing 107 breeding attempts distributed as 37 in 2009, 17 in 2010, 28 in 2011, 14 in 2012, and 11 in 2013 representing a statistically non-significant decline over time ($r_s = -0.90$, $P = 0.083$) (Fig. 2). Most territories were used only once ($N = 64$, 76.2%); 17 (20.2%) were used twice (five in two consecutive years and 12 on non-consecutive years), and three territories (3.6%) were used three times (two in consecutive years, one in not consecutive years). Minimum distance between territories was 147 m, with an average of 989 m \pm 882 (SD). Most nested in solitary pairs (82 territories, 97.6%) with one case of a two-pair cluster. Minimum distance with a territory of Lesser Grey Shrike was 36 m, with an average equal to 147 m \pm 211 (SD). There were seven cases of Woodchat Shrikes associating with single pairs of Lesser Grey Shrike ($N = 6$, 85.7%) or two-pair cluster ($N = 1$). One solitary pair nested in association with a two-pair cluster of Lesser Grey Shrike Shrikes.

I found only three nests (see Tab. 1 for a summary) of which all were built in isolated trees, one each in an Almond, Olive, and Chestnut (*Castanea sativa*), at an average height of 3.3 m (SD = 0.5 m). Two nests were partially hidden (66.6%) and two of them were horizontally placed in a proximal position (66.6%) and in a central vertical position. Average distance to buildings was 178 m and average distance to roads was 30 m. I found 17 families of Woodchat Shrike,

composed on average of 1.88 juveniles \pm 0.86 (SD); most of them had one juvenile ($N = 7$, 41.2%) but two ($N = 5$, 29.4%) or three ($N = 5$, 29.4%) juveniles were also seen.

DISCUSSION

This research describes new observations on the nesting ecology of Lesser Grey and Woodchat shrikes in southern Italy. The number of territories occupied yearly by both the species decreased between 2009 and 2013, though this decline was not statistically significant; this pattern followed the generally negative trend in shrike population numbers in Italy. The Lesser Grey Shrike has declined an unknown magnitude, whereas Woodchat Shrike numbers have declined by 70-80% (Nardelli et al. 2015, BirdLife International 2017). From one year to the next, nearly 30% of the territories were occupied again by the Lesser Grey Shrike which indicates some fidelity to nesting site. Although shrikes were not individually marked, this rate of territory re-use is similar to rates of site-fidelity found in other studies (Harris & Franklin 2000). In a study conducted in Slovakia, more than 30% of all nests were built in the same nest tree in successive years and 57.4% of the nests in the same or in a neighbouring tree (Krištín et al. 2007). Site fidelity may simply reflect conspecific attraction or selection for specific habitat features (Krištín et al. 2007). However, it seems that nest-site tradition is maintained if nests were successful in previous years, even though fledgling success may not be enhanced (Hoi et al. 2012). More than 20% of territories of Woodchat Shrike were re-used in successive years. This is not surprising, because 26-66% of the adults were back in the same area and natal fidelity ranges from 2 to 32% from one year to the next (Lefranc & Worfolk 1997). Both species nest mainly as solitary pairs. In about 5% of nestings two pairs of Lesser Grey Shrikes may cluster together which is a common habit of this species (Lefranc & Worfolk 1997, Harris & Franklin 2000) with 2-10 pairs often nesting close together and separated by 100-150 m (Lefranc & Worfolk 1997, Harris & Franklin 2000). I

found two pairs of Woodchat Shrike nesting together only one time. Like the Lesser Grey Shrike, the Woodchat Shrike also nests in small groups, even though this tendency is less pronounced (Cramp & Perrins 1993, Lefranc & Worfolk 1997). I found a close nesting association between these two species, involving 5.5% and 8.3% of pairs of Lesser Grey and Woodchat Shrike, respectively, with the minimum distance between nests of 36 m. This behaviour is already known (Cramp & Perrins 1993, Harris & Franklin 2000, Guerrieri & Castaldi 2010), and likely occurs because both species occur in similar habitat and an heterospecific social attraction between them seems to exist (Chiatante 2019) as indicated by both mixed pairs and hybrids (Lefranc et al. 2017).

In Apulia, the Lesser Grey Shrike nests mainly on isolated trees, building a nest at 4.2 m from the ground, partially hidden and placed in a distal position respect the tree trunk. Nest trees most commonly selected are oaks and elms as well as Almond and Olive in orchards, all as have been commonly reported (Cramp & Perrins 1993, Krištín 1995, Lefranc & Worfolk 1997, Krištín et al. 2000, Guerrieri & Castaldi 2010). In France Lesser Grey Shrikes nest in trees, especially in Planes (*Platanus* sp.), isolated or located along roadsides (Isenmann & Debout 2000), and in the Hungarian Puszta it nests in Poplars (*Populus* sp.) and in Black Locust (Bártol & Lovász 2000, Lovász et al. 2000). In orchards, the species nests also in fruit trees, such as Pear (*Pyrus communis*), Apple (*Malus pumila*), Walnut (*Juglans regia*), Cherry (*Prunus avium*), and Plum (*Prunus domestica*) trees (Krištín 1995, Wirtitsch et al. 2001), as well as in Almonds in Sicily (Salvo 1988) as I have found. Lesser Grey Shrikes generally avoid large olive orchards (Chiatante 2019) and I do not find any literature reporting *Olea* sp. as a nest tree. The use of *Quercus* sp. as support is uncommon (Isenmann et al. 2000, Guerrieri & Castaldi 2010) and the selection of Macedonian Oak (*Quercus trojana*) is a new finding even though this oak occurs also in the Balkan Peninsula and in Turkey (Barstow & Harvey-Brown 2017), where this shrike is relatively

well distributed (BirdLife International 2016). I found more than 15% of nests in shrubs of Almond-leaved Pear (*Pyrus amygdaliformis*), which is unusual (Cramp & Perrins 1993, Lefranc & Worfolk 1997, Harris & Franklin 2000). These atypical nest sites were found exclusively in the north-western Murgia Plateau, where the landscape is dominated by grasslands, scattered shrubs and very few trees. In another study in central Italy, the Lesser Grey Shrike nested on shrubby European Wild Pear (*Pyrus pyraster*) and in an open landscape with scattered shrubs and trees (Guerrieri & Castaldi 2010). In Turkey nests were built at 1.5-3.0 from the ground in Willow-leaved Pear (*Pyrus salicifolia*) (Panov 2011). The use of old nests of Magpie that I found is an already known habit (Cramp & Perrins 1993, Lefranc & Worfolk 1997). At last, the relatively short distance with rural infrastructures I found, shows a tendency for Lesser Grey Shrike to tolerate a slight amount of human presence as already observed in Apulia (Chiatante 2019) and elsewhere (Krištín 1995, Sfougaris et al. 2014), although human disturbance may be a threat for it (Tucker & Heath 1994, Bártol & Lovász 2000).

I found only three nests of Woodchat Shrike. These nests were built in isolated trees, at an average height of 3.3 m, partially hidden, and at an average distance of 178 m from buildings, all characteristics expected for this species (Cramp & Perrins 1993, Lefranc & Worfolk 1997, Harris & Franklin 2000).

Successful Lesser Grey Shrikes were seen with an average of 2.3 (1-4) juveniles, and successful Woodchat Shrikes with 1.9 (1-3) juveniles. This value for Lesser Grey Shrikes is in line with what is known for Italy (2.3-2.6 juv./pair; Brichetti e Fracasso 2011). In central Italy Guerrieri & Castaldi (2010) found pairs followed by 4.3 juveniles. The higher number of juveniles fledged in Spain (4.3 juv./pairs) and in Slovakia (4.1-6.0 juv./pairs) represent surviving chicks still in the nest (Krištín et al. 2000, Hoi et al. 2004, Giralte et al. 2008). My estimates of productivity is higher than that found in Hungary and Mediterranean France, where 0.7-1.2 and 1.9 juv./pairs were observed respectively (Lovász et

al. 2000, Lepley et al. 2004). For the Woodchat Shrike, productivity was quite low compared with productivity values from most other studies: Istria (1.53 juv./pair; Guglielmi & Tasso 2015), Italy (3.1 juv./pair; Guerrieri e Castaldi 2000), Spain (5.0 juv./pair; Hernández 1993), central Europe (2.4-4.6 juv./pair; Cramp e Perrins 1993), Bulgaria (5.5 juv./pair; Nikolov 2005), and Algeria (4.4 juv./pair; Brahimia et al. 2003). The Apulian productivity value could be biased inasmuch in some cases the brood division have been recorded for both species with each parent attending to specific young (Harris & Franklin 2000), although sometimes juveniles of Woodchat Shrike may break away from their family and join another (Cramp & Perrins 1993, Panov 2011).

Acknowledgements

I thank Pietro Chiatante for the help in the fieldwork. I thank Peter Lowther for helping to edit the manuscript through the AFO Editorial Assistance Program.

REFERENCES

- Barstow M. & Harvey-Brown Y., 2017. *Quercus trojana*: The IUCN Red List of Threatened Species 2017: e.T78978295A78978298.
- Bártol I. & Lovász P., 2000. Habitat selection and reproductive success of the Lesser Grey Shrike (*Lanius minor*) in the Kiskunság area. *Ornis Hung.* 10: 87–91.
- Bibby C.J., Burgess N.D., Hill D.A. & Mustoe S.H., 2000. *Bird census techniques* (2nd Edition). Academic Press, London, UK.
- BirdLife International., 2016. *Lanius minor*: The IUCN Red List of Threatened Species 2016: e.T22705038A87339356.
- BirdLife International., 2017. *European birds of conservation concern: populations, trends and national responsibilities*. BirdLife International, Cambridge, UK.
- Brahimia Z., Dziri H., Benyacoub S., Chabi Y. & Bañbura J., 2003. Breeding ecology of Algerian woodchat shrikes *Lanius senator*: low breeding success. *Folia Zool.* 52: 309–316.
- Brambilla M., Casale F., Bergero V., Crovetto G.M., Falco R., Negri I., Siccardi P. & Bogliani G., 2009. GIS-models work well, but are not enough: Habitat preferences of *Lanius collurio* at multiple levels and conservation implications. *Biol. Conserv.* 142: 2033–2042.
- Brichetti P. & Fracasso G., 2011. *Ornitologia Italiana*. Vol 7 - Paridae-Corvidae. Alberto Perdisa editore, Bologna, IT.
- Ceresa F., Bogliani G., Pedrini P. & Brambilla M., 2012. The importance of key marginal habitat features for birds in farmland: an assessment of habitat preferences of Red-backed Shrike *Lanius collurio* in the Italian Alps. *Bird Study* 59: 327–334.
- Chiatante G., 2019. Heterospecific social attraction in migrant birds: habitat niche overlap between two threatened shrikes. *Wildl. Res.* 46: 25.
- Chiatante G., Brambilla M. & Bogliani G., 2014. Spatially explicit conservation issues for threatened bird species in Mediterranean farmland landscapes. *J. Nat. Conserv.* 22: 103–112.
- Cramp S. & Perrins C.M., 1993. *Handbook of the birds of Europe, the Middle East and North Africa. Vol VII Flycatchers to Shrikes*. Oxford University Press, New York, US.
- Froehly J.L., Tegeler A.K., Jachowski C.M.B. & Jachowski D.S., 2019. Effects of scale and land cover on loggerhead shrike occupancy. *J. Wildlife Manage.* 83: 426–434.
- Giralt D., Brotons L., Valera F. & Krištín A., 2008. The role of natural habitats in agricultural systems for bird conservation: the case of the threatened Lesser Grey Shrike. *Biodivers. Conserv.* 17: 1997–2012.
- Guerrieri G. & Castaldi A., 2000. Selezione di habitat e riproduzione dell'averla capirossa, *Lanius senator*, nel Lazio - Italia Centrale. *Avocetta* 24: 85–93.
- Guerrieri G. & Castaldi A., 2010. Selezione di habitat e riproduzione dell'averla cenerina, *Lanius minor*, in un'area costiera del Lazio (Monti della Tolfa). *Riv. ital. Ornit.* 80: 35–56.
- Guglielmi R. & Tasso M., 2015. Considerations on population ecology of Red-backed shrike (*Lanius collurio* Linnaeus, 1758) and Woodchat shrike (*Lanius senator* Linnaeus, 1758) within bird communities in an area of Western Istria. *Nat. Croat.* 24: 127–138.
- Harris T. & Franklin K., 2000. *Shrikes & bush-shrikes: including wood-shrikes, helmet-shrikes, flycatcher-shrikes, philentomas, batises and wattle-eyes*. Christopher Helm, London, UK.
- Hernández A., 1993. Estudio comparado sobre la biología de la reproducción de tres especies simpátricas de alcudones (real *Lanius excubitor*, dorsirrojo *L. collurio* y comun *L. senator*). *Acta Vertebrata* 20: 179–250.
- Hoi H., Krištín A., Valera F. & Hoi C., 2004. Clutch enlargement in Lesser Gray Shrikes (*Lanius minor*) in Slovakia when food is superabundant: a maladaptive response? *Auk* 121: 557–564.
- Hoi H., Krištín A., Valera F. & Hoi C., 2012. Traditional versus non-traditional nest-site choice: alternative deici-

- sion strategies for nest-site selection. *Oecologia* 169: 117–124.
- Isenmann P. & Debout G., 2000. Vineyards harbour a relict population of Lesser Grey Shrike (*Lanius minor*) in Mediterranean France. *J. Ornithol.* 141: 435–440.
- Isenmann P., Debout G. & Lepley M., 2000. La Pie-grièche à poitrine rose *Lanius minor* nicheuse à Montpellier (sud France). *Alauda* 68: 123–131.
- Isenmann P. & Fradet G., 1998. Nest site, laying period, and breeding success of the Woodchat Shrike (*Lanius senator*) in Mediterranean France. *J. Ornithol.* 139: 49–54.
- Krištín A., 1995. Why the Lesser Grey Shrike (*Lanius minor*) survives in Slovakia: Food and habitat preferences, breeding biology. *Folia Zool.* 44: 325–334.
- Krištín A., Hoi H., Valera F. & Hoi C., 2000. Breeding biology and breeding success of the Lesser Grey Shrike *Lanius minor* in a stable and dense population. *Ibis* 142: 305–311.
- Krištín A., Hoi H., Valera F. & Hoi C., 2007. Philopatry, dispersal patterns and nest-site reuse in Lesser Grey Shrikes (*Lanius minor*). *Biodivers. Conserv.* 16: 987–995.
- van Laar A. & Akça A., 2007. *Forest mensuration*. Springer, Dordrecht (NL).
- Lefranc N., Brunet C. & Schreiber A., 2017. Un couple mixte Pie-grièche à poitrine rose x Pie-grièche à tête rousse dans les Vosges. *Ornithos* 24: 108–117.
- Lefranc N. & Worfolk T., 1997. *Shrikes. A guide to the shrikes of the world*. Pica Press, Mountfield, UK.
- Legendre P. & Legendre L., 1998. *Numerical ecology* (2nd ed). Elsevier, Amsterdam, NL.
- Lepley M., Ranc S., Isenmann P., Bara T., Ponel P. & Guilleman M., 2004. Diet and gregarious breeding in Lesser Grey Shrike *Lanius minor* in Mediterranean France. *Rev. Écol. (Terre Vie)* 59: 591–602.
- Lovász P., Bártol I. & Moskát, Csaba., 2000. Nest-site selection and breeding success of the Lesser Grey Shrike (*Lanius minor*) in Hungary. *Ring* 22: 157–164.
- Nardelli R., Andreotti A., Bianchi E., Brambilla M., Breciaroli B., Celada C., Dupré E., Gustin M., Longoni V., Pirrello S., Spina F., Volponi S. & Serra L., 2015. Rapporto sull'applicazione della Direttiva 147/2009/CE in Italia: dimensione, distribuzione e trend delle popolazioni di uccelli (2008-2012). ISPRA, Roma, IT.
- Nikolov B.P., 2005. Reproductive success of the Woodchat Shrike (*Lanius senator*) in Western Bulgaria. *Ornis Fennica* 82: 73–80.
- Panov E.N., 2011. *The true shrikes (Laniidae) of the world*. Pensoft, Sofia, BG & Moscow, RU.
- R Core Team., 2019. *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Wien.
- Rondinini C., Battistoni A., Peronace V. & Teofili C. (Eds.), 2013. *Lista Rossa IUCN dei Vertebrati Italiani*. Comitato Italiano IUCN e Ministero dell'Ambiente e della Tutela del Territorio e del Mare, Roma, IT.
- Salvo G., 1988. Note sulla biologia dell'averla cenerina, *Lanius minor*, in Sicilia. *Riv. ital. Ornit.* 58: 96–98.
- Sfougaris A.I., Plexida S.G. & Solomou A.D., 2014. Assessing the effects of environmental factors on the presence and density of three shrike species in a continental and a coastal area of central Greece. *North-West. J. Zool.* 10: 101–109.
- Smith E.L. & Kruse K.C., 1992. The relationship between land-use and the distribution and abundance of Loggerhead Shrikes in South-Central Illinois. *J. Field Ornithol.* 63: 420–427.
- Tryjanowski P. & Kuźniak S., 1999. Effect of research activity on the success of Red-backed Shrike *Lanius collurio* nests. *Ornis Fennica* 76: 41–43.
- Tucker G.M. & Heath M.F., 1994. *Birds in Europe: their conservation status*. BirdLife International, Cambridge, UK.
- Wirtitsch M., Hoi H., Valera F. & Krištín A., 2001. Habitat composition and use in the lesser grey shrike *Lanius minor*. *Folia Zool.* 50: 137–150.
- Yosef R., 1994. Evaluation of the global decline in the true shrikes (family *Laniidae*). *The Auk* 111: 228–233.
- Yosef R. & Deyrup M.A., 1998. Effects of fertilizer-induced reduction of invertebrates on reproductive success of Loggerhead Shrikes (*Lanius ludovicianus*). *J. Ornithol.* 139: 307–312.
- Yosef R. & Lohrer F.E., 1995. Shrikes (Laniidae) of the World: biology and conservation. *Proc. West. Found. Vert. Zool.* 6: 1–343.

This work is licensed under the Creative Commons Attribution-ShareAlike 4.0 International License. To view a copy of this license, visit <http://creativecommons.org/licenses/by-sa/4.0/>.



Received: 7 June 2020
 First response: 17 July 2020
 Final acceptance: 27 July 2020
 Published online: 16 October 2020
 Associate editor: Giulia Masoero