DIET AND GREGARIOUS BREEDING IN LESSER GREY SHRIKE *LANIUS MINOR* IN MEDITERRANEAN FRANCE

Michel LEPLEY[1,2,3], Sébastien RANC[2], Paul ISENMANN[4], Thierry BARA[2], Philippe PONEL[5] & Matthie GUILLEMAIN[6]

RÉSUMÉ

Le régime alimentaire de la Pie-grièche à poitrine rose *Lanius minor* a été étudié entre 1993 et 2000 au sein des deux dernières colonies françaises de reproduction de l'espèce, situées en zone méditerranéenne (Basse plaine de l'Aude et plaine de Poussan). L'analyse de pelotes de réjection et de fonds de nids a permis d'identifier 2 115 proies. Conformément aux données de la littérature en provenance d'autres régions (Russie, Europe Centrale et de l'Est), les principales proies sont des Coléoptères, ainsi que des Orthoptères en période d'élevage des jeunes. Les relations entre le comportement grégaire de nidification et le régime alimentaire de l'espèce ont été étudiées en 2000 en Basse plaine de l'Aude. Au sein de cette colonie, les couples nichaient soit en agrégat soit isolément. Le régime alimentaire différait significativement entre les familles grégaires et les familles isolées ($P < 0.001$). Cette différence était due à trois espèces proies seulement : *Amphimallon pygialis* (Mélolonthidés), *Anisoplia tempestiva* (Rutélidés) et *Decticus albifrons* (Ensifère). Celles-ci composaient en effet plus de 60 % de la biomasse totale des proies ingérées par les familles grégaires, contre moins de 10 % pour les familles isolées. Par ailleurs, les nids des couples grégaires se trouvaient à proximité immédiate de prairies (en moyenne 25 % de la surface totale dans un rayon de chasse de 150 m), alors que ceux des couples isolés étaient dans des secteurs dépourvus de prairies (habitats majoritairement composés de vignes et de cultures céréalières et maraîchères). Or, les espèces-proies majeures citées précédemment sont des espèces de zones herbeuses. Elles sont donc potentiellement favorisées par la présence des prairies, bien que d'autres habitats tels que les friches et les bords herbeux de cultures puissent leur convenir. Néanmoins, il n'a pas été possible de mettre en évidence une relation entre ces espèces-proies et le succès de la reproduction des pies-grièches. Cependant, il n'est pas exclu qu'elles puissent, chez les familles grégaires, être avantageuses d'un point de vue énergétique et nutritionnel, pour les adultes et pour les jeunes (croissance) et pour leur survie durant la migration.

[1] 5, rue de la République, F-30300 Fourques. Tél. : 04 90 49 92 97.
E-mail : michel.lepley@wanadoo.fr

[2] GRIVE, Espace République de l'Hôtel de Région, 20 rue de la République, F-34000 Montpellier.

[3] EPHE, Laboratoire de Biogéographie et Ecologie des Vertébrés, Université de Montpellier II, place Eugène Bataillon, F-34095 Montpellier Cedex 5.

[4] CEFE/CNRS (UPR9056), 1919 route de Mende, F-34293 Montpellier Cedex 5.

[5] IMEP-CNRS-UPRES A 6116 (service 451), F-13397 Marseille Cedex 20.

[6] ONCFS, CNERA Avifaune Migratrice, Station Biologique de la Tour du Valat, F-13200 Le Sambuc.

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SUMMARY

The diet of the Lesser Grey Shrike *Lanius minor* was studied between 1993 and 2000 in the two last French breeding colonies, located in Mediterranean area ("Basse Plaine de l'Aude" and "Plaine de Poussan"). Pellets and remains of nest analyses provided a total of 2115 prey. In accordance with the literature from other areas (Russia, Eastern and Central Europe), main prey in France were beetles, grasshoppers and locusts during the nestling and fledgling periods. The relationship between gregarious nesting behaviour and diet was studied in 2000 in the Basse Plaine de l'Aude. In this colony, some breeding pairs were aggregated whereas some others were not. The diet differed significantly between the aggregated and the isolated families ($P < 0.001$). This difference was due to only three prey species: *Amphimallon pygialis* (Melolonthidae), *Anisoplia tempestiva* (Rutelidae) and *Decticus albifrons* (Ensifera). These prey constituted more than 60% of the total biomass ingested by the gregarious families, versus less than 10% for the isolated ones. The gregarious pairs built their nests near meadows (on average 25% of the surface in a 150 m hunting radius), whereas the isolated pairs built their nests without meadows around (only with vineyards, cereals and market gardener cultures). The three main prey species above could be found in grassy area like meadows, but also in fallows and grassy field margins. These main prey did not seem to have a positive effect on the breeding success. However, they may provide, in the aggregated families, other energetic and nutritional benefits to adults and young (growth), therefore for their survival during migration.

INTRODUCTION

The Lesser Grey Shrike *Lanius minor* has declined markedly during the last century, in terms of both numbers of individuals and range (Cramp & Perrins, 1993; Lefranc, 1993, 1994, 1999; Tucker & Heath, 1994). Even if data from the oriental part of the breeding area (Russia) are lacking, it is well established that this species disappeared from several European countries, and is still declining in others (Krištín & Lefranc, 1997). In France, its decline has been dramatic (Lefranc, 1978; Bara & Lefranc, 1999) and only two breeding colonies of approximately 20 pairs each remain (Bara, 1995; Bechet *et al.,* 1995). The main factors thought to be responsible for this pattern are climatic changes (Lefranc & Worfolk, 1997), intensification of agriculture (Yosef, 1994; Lefranc, 1997), predation of eggs and chicks by corvids (Krištín *et al.,* 2000) and problems linked to wintering and migration (Herremans, 1998).

The Lesser Grey Shrike is still poorly known, apart from a few studies on its feeding ecology out of the Mediterranean area (Rashkevich, 1956; Haensel, 1964; Schmidt, 1980; Krištín, 1995; Panow, 1996; Krištín *et al.,* 1998; Krištín & Zilinec, 1998; Valera *et al.,* 2001; Krištín *et al.* 2002; Valera & Krištín, 2002), its breeding ecology (Bara, 1995; Isenmann *et al.,* 2000; Krištín *et al.,* 2000; Lovászi *et al.,* 2002) and habitat selection (Guerrieri *et al.,* 1995; Isenmann & Debout, 2000; Wirtitsch *et al.,* 2001). Krištín *et al.* (2000) showed that the level of breeding gregariousness had no effect on the breeding success, while other authors showed the opposite (Isenmann *et al.,* 2000; Valera *et al.* 2003). Nonetheless the former suggested that a link may exist between gregariousness, food resources and nesting sites.

In the present study, our objective is first to describe the diet of the Lesser Grey Shrike in the Mediterranean area. We then compare the diet of isolated and gregarious families, and eventually try to assess potential relationships between diet and breeding habitat characteristics on the one hand, and diet and breeding success on the other.

METHODS

Diet description in the Mediterranean area

The last two French breeding colonies were studied from 1993 to 2000. Both are located in the Mediterranean area, in the departments of Hérault (Plaine de Poussan) and Aude (Basse Plaine de l'Aude), and consist of ca. 20 pairs each. Prey were identified (to the species) from pellets and remains found in nests. A total of 2115 prey items were identified (Plaine de Poussan: 450; Basse Plaine de l'Aude: 1665). Items were determined after reference collections of specimens (i.e. complete prey individual) and of their different organs. Biomasses were estimated after weights of live specimens. In the Plaine de Poussan, only the diet of gregarious adults was studied, from late May to late June. In the Basse Plaine de l'Aude, the study periods corresponded to egg-laying and incubation (late May to mid-June), chick rearing (second half of June to early July) and the period of juveniles feeding (next four weeks). Each pellet collected could be related to one of these periods. It was not possible to determine if pellets found after hatching had been produced by the adults or by the juveniles, because these were mostly collected on the ground under the nests.

In order to test for differences in diet between the two colonies, and between the different periods of breeding in the Basse Plaine de l'Aude, fresh biomasses were compared using χ-square tests (Scherrer, 1984). Each prey species whose biomass was lower than one gram was included with related species in a taxa of higher rank (i.e. family instead of species). Eventually, less than 20% of cases were between one and five grams.

Relationships between diet and gregariousness

Gregariousness was only studied in year 2000 in the Basse Plaine de l'Aude colony. Simultaneous and successive observations (Ranc, 2000) allowed determining precisely the position of nests, therefore assessing whether each of these could be considered "gregarious" or "isolated" (see under). A total of 20 nests were recorded.

Nests were on average 2219 m apart from each other (n = 210 measures, standard deviation = 1696 m). In a small group of 8 nests, limited by a highway and the Aude river, average inter-nest distance was only 419.11 m (n = 28 measures, standard deviation = 189.5 m). The nests were considered "gregarious". The other nests, scattered, were on average 2496.35 m apart from each other (n = 78 measures, standard deviation = 1654.44 m), and were therefore considered "isolated".

The diet of gregarious pairs (6 pairs studied plus one whose nest could not be found) and isolated pairs (5 pairs studied) was compared after the analysis of 111 pellets, for a total of 1246 prey corresponding to an estimated fresh biomass of 416.77 g.

In order to test for differences in diet between gregarious and isolated families, χ-square tests were used again, following the same procedure as above. Eventually, in order to assess which taxa were responsible for the observed differences, these were discarded one after the other from the analyses in a stepwise procedure (starting by those whose biomasses were the most different) until the difference between the two types of bird families was no longer significant.

Relationships between habitat characteristics and gregariousness

For each nest whose family was included in the pellet collection, the characteristics of the surrounding hunting habitat were assessed. This was done in a radius of ca. 150 m around the nest, corresponding to the most common hunting distance for this bird species (Lefranc & Worfolk, 1997). Each land lot was identified according to the type of cultivation there during the breeding period of the Lesser Grey Shrike (i.e. vineyards, fallows, meadows...), and areas were calculated for each crop type. The overall aim of this was to assess potential relationships between hunting habitat, diet and gregariousness.

Relationships between gregariousness and breeding success

The breeding success of each pair whose pellets were collected was evaluated by the number of fledged young. The overall aim of this was to assess the potential effect of gregariousness on breeding success.

RESULTS

Diet description in the Mediterranean area

In the "Plaine de Poussan" as well as in the "Basse Plaine de l'Aude", the diet of the Lesser Grey Shrike was mainly based on invertebrates (100% and 96%, respectively). Coleoptera were dominant (70% and 29%; Table I), especially Scarabei-

Table I

Diet of adult Lesser Grey Shrike Lanius minor *in the last two French colonies (Mediterranean area), from 1997 to 2000 (% fb = percentage of estimated fresh biomass)*

Taxa		P. Poussan	B.P. Aude
Ranks	Determined	% fb	% fb
Arachnida	Araneae Undet.	0.34	0.43
	Opiliones Undet.	1.37	0.04
Crustacea	Crustacea Undet.	2.93	0.38
Chilopoda	*Scolopendra cingulata* Latreille	-	1.56
Orthoptera	*Tettigonia viridissima* (L.)	2.28	15.58
	Decticus albifrons (Fabricius)	-	7.12
	Tettigoniidae Undet.	11.77	2.96

TABLE I (continued)

Taxa		P. Poussan	B.P. Aude
Ranks	Determined	% fb	% fb
	Gryllus campestris (L.)	1.30	-
	Gryllus sp	-	0.32
	Gryllidae Undet.	-	5.97
	Anacridium aegyptium (L.)	-	6.46
	Euchorthippus sp	-	0.11
	Caelifera Undet.	0.93	3.27
	Orthoptera Undet.	0.21	-
Dermaptera	*Euborellia moesta* (Géné)	0.26	0.06
Homoptera	Cicadoidea Undet.	-	0.32
	Cicadoidea Undet. Larvae	-	4.36
Heteroptera	Heteroptera Undet.	1.85	0.17
Caraboidea	*Calosoma sycophanta* L.	1.70	1.41
	Acinopus picipes (Olivier)	0.82	0.09
	Carabidae Undet.	0.98	7.57
	Cicindelidae Undet.	0.45	-
	Caraboidea Undet.	9.18	6.66
Staphylinidae	*Ocypus olens* Müller	1.44	-
	Ocypus ophtalmicus (Scopoli)	0.10	-
	Tasgius pedator (Gravenhorst)	0.10	-
	Staphylinidae Undet.	1.70	-
Scaraboidea	*Onthophagus emarginatus* (Mulsant)	0.15	-
	Onthophagus vacca (L.)	0.21	-
	Amphimallon pygialis Mulsant	-	5.13
	Amphimallon ruficorne (Fabricius)	10.04	-
	Anoxia sp	-	0.78
	Melolonthidae Undet.	-	0.58
	Anisoplia tempestiva Erichson	-	2.66
	Pentodon bidens (Pallas)	-	3.14
	Pentodon sp	1.70	0.79
	Tropinota sp	1.61	-
	Oxythyrea funesta (Poda)	1.03	-
	Cetonia aurata (L.)	4.89	-
	Netocia oblonga (Gory & Percheron)	0.82	-
	Netocia morio (Fabricius)	2.93	-
	Cetoniidae Undet.	4.94	0.35
	Scarabaeidae Undet.	0.86	0.57
	Scarabaeoidea Undet.	3.58	1.85
Tenebrionidae	*Scaurus atratus* Fabricius	1.23	-
	Opatrum cf. *sabulosum* (L.)	6.48	0.21
Alleculidae	*Omophlus lepturoides* (Fabricius)	3.02	-
	Megischina curvipes (Brullé)	0.12	-
Cerambycidae	*Capnodis tenebricosa* (Olivier)	-	0.21
	Latipalpis plana (Olivier)	0.98	-

TABLE I (continued)

Taxa		P. Poussan	B.P. Aude
Ranks	Determined	% fb	% fb
	Stenopterus rufus (L.)	0.12	-
Curculionidae	Curculionidae Undet.	1.15	2.58
Other Col.	Coleoptera Undet.	7.62	2.99
Hymenoptera	Formicidae Undet.	1.01	0.20
	Hymenoptera Undet.	4.51	0.35
Lepidoptera	Lepidoptera Undet. Larvae	0.86	9.04
Mollusc	Snail Undet.	0.43	0.18
Vertebrates	Microrodent Undet.	-	3.55

dae (33% and 15%) and Carabidae (13% and 8%), as well as Orthoptera (17 and 58%), especially Tettigoniidae (14 and 39%). There was however a significant difference in diet between the two colonies ($\chi^2 = 18$, df = 2, $P < 0.001$), as the use of Orthoptera was higher in the Basse Plaine de l'Aude. At the beginning of the breeding period, Coleoptera were the most abundant (73% in the Basse Plaine de l'Aude; Table III), with a major use of Melolonthidae by the adults (27%). The diet of the chicks also comprised a large share of Coleoptera (64%; Table II), even if Lepidoptera larvae were also well represented (19%). Across the breeding cycle, the part of the diet made of Orthoptera (as opposed to Coleoptera) increased (until 66% and 64% during the period of chick and juvenile rearing, respectively; Table III). There was a significant difference in diet between successive periods of the breeding cycle ($\chi^2_8 = 63$, $P < 0.001$).

TABLE II

Diet of Lesser Grey Shrike Lanius minor *chicks in the Basse Plaine de l'Aude in 1993 (% fb = percentage of estimated fresh biomass)*

Taxa		
Ranks	Determined	% fb
Arachnida	Opiliones Undet.	1.46
Orthoptera	Tettigoniidae Undet.	8.90
	Caelifera Undet.	3.36
Heteroptera	Heteroptera Undet.	1.75
Coleoptera	Caraboidea Undet.	15.03
	Amphimallon pygialis Mulsant	9.20
	Cetonia aurata (L.)	8.32
	Scarabaeoidea Undet.	17.52
	Curculionidae Undet.	1.75
	Coleoptera Undet.	12.12
Hymenoptera	Hymenoptera Undet.	1.17
Lepidoptera	Lepidoptera Undet. Larvae	19.42

TABLE III

Diet of the Lesser Grey Shrike Lanius minor *in year 2000 in the Basse Plaine de l'Aude, across the different periods of the breeding cycle (% fb = percentage of estimated fresh biomass)*

Taxa		Incubation	Nestlings	Fledglings
Ranks	Determined	% fb	% fb	% fb
Arachnida	Araneae Undet.	-	0.03	-
	Opiliones Undet.	-	-	0.23
Crustacea	Crustacea Undet.	0.55	0.08	0.71
Odonata	Anisoptera Undet.	-	0.08	-
Orthoptera	*Tettigonia viridissima* (L.)	3.84	2.67	5.99
	Decticus albifrons (Fabricius)	6.49	33.46	40.89
	Platycleis cf. *falx* (Fabricius)	-	-	1.22
	Platycleis sp	-	1.43	0.45
	Tettigoniidae Undet.	8.77	2.93	2.89
	Gryllus sp	-	-	1.16
	Gryllidae Undet.	1.50	0.78	0.77
	Calliptamus sp	-	-	1.74
	Anacridium aegyptium (L.)	-	19.95	1.04
	Locusta migratoria (L.)	-	1.21	-
	Oedipoda caer. (L.) / *char.* (Fieber)	-	-	0.36
	Caelifera Undet.	3.35	3.73	7.32
Dermaptera	*Euborelia moesta* (Géné)	-	0.02	-
Homoptera	Cicadoidea Undet.	1.30	0.20	6.60
	Cicadoidea Undet. Larvae	-	0.04	-
Heteroptera	Heteroptera Undet.	-	0.11	0.71
Caraboidea	*Calosoma sycophanta* L.	2.86	1.19	-
	Acinopus picipes (Olivier)	0.35	-	-
	Carabidae Undet.	14.00	0.16	4.13
	Cicindelidae Undet.	-	0.06	-
	Caraboidea Undet.	13.22	2.70	2.18
Scaraboidea	*Onthophagus emarginatus* (Mulsant)	-	0.01	-
	Amphimallon pygialis Mulsant	12.11	7.57	2.23
	Anoxia sp	4.33	1.81	1.13
	Anisoplia tempestiva Erichson	10.82	2.41	0.56
	Pentodon algerinum (Herbst)	-	0.40	-
	Pentodon sp	-	1.81	-
	Oxythyrea funesta (Poda)	-	0.04	-
	Cetoniidae Undet.	-	-	0.60
	Scarabaeidae Undet.	2.34	2.86	3.49
	Scarabaeoidea Undet.	4.91	0.50	-
Chrysomelidae	Chrysomelidae Undet.	-	0.32	-
Curculionidae	Curculionidae Undet.	0.66	0.82	1.10
Other Col.	Coleoptera Undet.	7.13	4.85	4.28
Hymenoptera	Formicidae Undet.	0.75	0.19	0.84

TABLE III (continued)

Taxa		Incubation	Nestlings	Fledglings
Ranks	Determined	% fb	% fb	% fb
	Hymenoptera Undet.	-	0.88	1.96
Lepidoptera	Lepidoptera Undet. Larvae	-	0.53	2.99
Diptera	Diptera Undet.	-	-	1.76
Mollusc	Snail Undet.	0.72	0.15	0.41
Vertebrate	Microrodent Undet.	-	4.02	-
Vegetal	Seed Undet.	-	-	0.26

RELATIONSHIPS BETWEEN DIET, HABITAT CHARACTERISTICS AND GREGARIOUSNESS

In a 150 m radius around the nests, the habitat of isolated pairs was dominated by vineyards, cereals and market gardener cultures, without grasslands. Conversely, meadows averaged 25% of the hunting habitat of gregarious pairs (Table V).

During incubation, Melolonthidae (*Amphimallon pygialis*) and Rutelidae (*Anisoplia tempestiva*) made up a major part of the ingested biomass. During chick and juvenile rearing, *Decticus albifrons* (Tettigoniidae) became the most abundant in adults and young (Tables III and IV). However, isolated families made very little use of these three prey species compared to gregarious ones (Table IV). The overall diet of isolated and gregarious families therefore differed significantly ($\chi^2_8 = 153$, $P < 0.001$), and these three prey species were responsible for this difference.

TABLE IV

Proportions of the three main prey species in gregarious and isolated families across the different periods of the breeding cycle (Basse Plaine de l'Aude, 2000) (% fb = estimated fresh biomass)

	Taxa (% fb)			
	A. pygialis	*A. tempestiva*	*D. albifrons*	Others
Gregarious pairs				
Incubation	17.23	15.38	9.23	58.16
Nestling	9.75	3.95	52.86	33.44
Fledgling	1.99	0.93	60.09	36.99
Average PERIODS	8.03	4.09	50.98	36.90
Isolated pairs				
Incubation	0	0	0	100
Nestling	4.12	0	3.09	92.79
Fledgling	2.64	0	11.80	85.56
Average PERIODS	3.37	0	5.77	90.86

Relationships between gregariousness and breeding success

The number of fledged young seemed to be higher in isolated than in gregarious pairs (i.e. 2.5 versus 1.25, respectively). However, the sample size of families was small (Table V), preventing a proper statistical analysis and therefore to draw firm conclusions.

TABLE V

Habitat composition around nests and breeding success in the Basse Plaine de l'Aude (2000)

Nest number	Vineyards (%)	Meadows (%)	Fallows (%)	Others (%)	Nb of young
Gregarious pairs					
1	8	64	25	3	?
2	33	41	17	9	0
3	16	25	31	28	4
4	31	0	0	69	1
5	73	17	0	10	0
6	25	5	31	39	?
Average	31	25.4	17.3	26.3	1,25
Isolated pairs					
7	75	0	10	15	1
8	59	0	5	36	3
9	50	0	39	11	4
10	23	0	0	77	2
11	29	0	16	55	?
Average	47.2	0	14	38.8	2,50

DISCUSSION

The diet of the Lesser Grey Shrike in the Mediterranean area was similar to that described elsewhere in Eastern Europe and in Russia, as in all cases Coleoptera are the main prey, as well as Orthoptera to a lesser extent during reproduction (Rashkevich, 1956; Haensel, 1964; Schmidt, 1980; Krištín, 1995; Panow, 1996; Krištín *et al.,* 1998). However, this latter prey group does not seem to be equally important in all colonies.

During incubation and chick rearing, the Lesser Grey Shrike relies markedly on Melolonthidae or Rutelidae, like *A. pygialis* and *A. tempestiva* in our study. This was also observed in Southern Grey Shrike (*Lanius meridionalis*) with *Amphimallon ruficorne* (Lepley *et al.,* in press). The most remarkable case concerns the Cockchafer *Melolontha melolontha* which, during periods of peak abundance, can be almost the only prey taken by Lesser Grey Shrike (Haensel, 1964; Krištín & Zilinec, 1998). These results highlight the ability of shrikes, especially the Lesser Grey Shrike, to specialize on a limited number of prey species. This type of foraging behaviour is of course very risky if one or a few major prey species suddenly decline. In this context, Krištín & Zilinec (1998) related the decline of the Lesser Grey Shrike and the destruction of *M. melolontha* through major use of DDT during the last century (Hurpin, 1962; Robert *et al.,* 1986).

Meadows (Wirtitsch *et al.,* 2001; present study) and other grassy habitats (Isenmann & Debout, 2000) are potentially favourable to Coleoptera-Melolonthidae, as well as to Grasshoppers. This could positively affect the gregarious breeding behaviour of the Lesser Grey Shrike. However, it is not clear whether gregariousness affects breeding success, as in our study the results for this species were too scarce to test for a potential difference. In the population studied by Krištín *et al.* (2000) in Slovakia, the gregariousness of pairs did not have any effect on breeding success, while Isenmann *et al.* (2000) and Valera *et al.* (2003) showed the opposite, with a higher breeding success in gregarious pairs.

The gregarious breeding behaviour has not thus necessarily a positive effect on breeding success. However, this habitat-selective bird species (Guerrieri *et al.,* 1995) favours high quality hunting areas (Lovászi *et al.,* 2002) and good sized invertebrate prey (Krištín *et al.,* 1998). Consequently, an abundant source of food helps increasing brood size and chick mass (Krištín *et al.,* 2002). Large or abundant prey like Tettigoniidae or Melolonthidae (*M. melolontha* being known to be protein-rich, cf Juillard, 1984) probably allow energy saving by the parents, higher nutritive benefits for the young, and maybe provide a better body condition for the onset of migration to Southern Africa. These hypotheses require further investigations.

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