



BENEFITS OF HEDGEROW-WINDBREAKS FOR BIRDS AND THEIR ROLE IN SUSTAINABLE AGRICULTURE

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SUMMARY - This is one of the few investigations on hedgerow-windbreak effects that has been carried out in Mediterranean environments.

The role of hedgerow-windbreaks has always been associated with biodiversity enhancement and consequently with sustainable farming systems. Several positive ecological and environmental effects are recognised with this kind of vegetation. This paper reports the results of ten years of observations on the use that birds make of hedgerow-windbreaks in Sicily and the benefits they get from their presence.

The importance of this habitat for birds has been determined by comparing three agroecosystems representative of Mediterranean regions; it was shown that the presence of hedgerow-windbreaks is essential to birds for their main vital functions, allowing a more integrated use of the environment.

Key words: *hedgerows, windbreaks, benefit, bird diversity, sustainable agriculture.*

INTRODUCTION

The definition of sustainable agriculture, the discussion about which has lasted for over ten years (cf. Altieri, 1987), is still lacking (Neher, 1992; Schaller, 1993). Sustainability is directly related to the concept of diversity; low input techniques in an agroecosystem lead to an increase of biodiversity, which in turn is considered "a key to ecosystem sustainability" (Robinson, 1991). The application of modern technologies, mainly intensive mechanisation, has required the simplification of the agricultural system with a consequent disruption of most of the elements of the diversity. In many European countries, in spite of the continuous processes for their removal (O'Connor and Shrubbs, 1986; Tivy, 1990; Lack, 1992), hedgerows represent the only natural permanent form of vegetation to day present in some rural landscapes.

Hedgerows have several, complex functions, but often the most well-known is their activity as windbreaks (Brandle and Hintz, 1988; Barbera and La Mantia, 1991; Caporali, 1991). The effect of hedgerows on wildlife is important as

their presence significantly increases biotic diversity; this effect is explained by complex mechanisms influenced by the type of vegetation forming hedgerows (trees, shrubs), the plant species and age, and the landscape where hedgerows are implanted (A.A. V.V., 1980; Lack, 1992; Paoletti *et al.*, 1992). In the agroecosystems every form of permanent vegetation is very important as breeding, shelter, roosting and feeding site for wildlife, and it often represents the only important vegetation form during the autumn-winter months which is not removed every year. Wildlife lives in this particular "linear" habitat (Johnson and Beck, 1988), which however for its dimension and isolation, cannot be considered as "one ecological unit", since many species living, nesting or roosting there, depend on the surrounding habitats for feeding. Hedgerows play the role of ecological corridors allowing some species to move through unsuitable habitats (Crowe, 1970).

Relationships between hedgerows and birds have been thoroughly analysed in the past and many reviews about this subject are available (Pollard *et al.*, 1974; Constant *et al.*, 1976;

O'Connor and Shrubbs, 1986; Lack, 1992). These studies revealed the existence of positive relations between birds living in hedgerows and their surrounding habitats (also cultivated land) and only in rare cases did they show that the presence of hedgerows produces negative effects on agriculture; the latter relation is mainly due to the fact that some species of birds may feed on fruits, buds or flowers (Wright *et al.*, 1980). Some aspects of this controversial problem are discussed by La Mantia and Massa (1995); however it is well known that the relationship between hedgerow vegetation and birds is always of reciprocal advantage because birds provide dissemination of hedgerow plant seeds (Herrera, 1982; McDonnell in Caporali, 1991) and contribute to facilitate the diffusion of wood plants in areas outside woods (Burel and Baudry, 1990).

The role of hedgerows has mainly interested the central and northern European countries and the United States. Recent studies were carried out in central and northern Italy (Groppali, 1991), but studies about the role of hedgerows for birds in Mediterranean regions are lacking. The present study reports the results of ten years of observations on the use and benefits of hedgerows for the birds on a Mediterranean island.

MATERIALS AND METHODS

Our research has been carried out in some hedgerow-windbreaks of different agroecosystems of inland Sicily (Italy), in the provinces of Palermo, Trapani and Agrigento. The hedgerows were situated mainly at the edge of open fields under cereals or pastures with some rare trees (almonds or olives), at an altitude ranging between sea level and 1.000 m a.s.l. The sites were of three types characterized by different vegetative structure: a) linear rows dominated by 1-3 of the following species: *Acacia* spp., *Cupressus* sp., *Pinus* spp., *Fraxinus* sp., *Laurus nobilis*, *Ulmus minor*, *Salix* sp., sometimes *Opuntia ficus-indica* and *O. amyntia*; b) linear rows as above, also including shrubby species as *Rhus coriaria*, *Cratae-*

gus spp., *Spartium junceum*, *Calycotome* spp., *Prunus spinosa*, *Rosa* sp., *Rubus ulmifolius*; c) linear rows of tree species as a) with 1-2 rows of shrubby species (as reported in b) at the edge.

Because of heterogeneity and random selection these samples can be considered as representative of the greater part of lowland and hill agroecosystems in Sicily and possibly of many of the other Mediterranean agroecosystems.

Censuses of birds have been carried out by the E.F.P. method (*Echantillonnages Fréquentiels Progressifs*: Blondel, 1975; Blondel *et al.*, 1981), which allows the evaluation of the frequency of occurrence of species living in each habitat type from the records of bird individuals detected in different point counts by their songs or by direct observation for 20 minutes; the presence/absence of each species gives the frequency of occurrence (%) in each habitat. Compared to quantitative methods, this sampling method is time saving (each station is counted only once and the observer may census many point counts in a season), even though it does not allow absolute densities to be obtained; moreover it permits different bird populations living in different habitats (in our case, in different types of hedgerows) to be compared and yields reliable richness values of a bird community (Blondel *et al.*, 1981). Values have been subdivided into four categories of frequency: frequency less than 25% (scarce), between 26% and 50% (moderate-scarce), between 51% and 75% (moderate-high) and between 76% and 100% (high).

Breeding birds were censused in 275 different point counts evenly distributed in the three hedgerows types, between the 15th of May and the 15th of July in 1982-92. During the winter (November to February) of each year, censuses were repeated in the same point counts, in order to yield data on the frequency of wintering birds.

The phenology of bird species has been drawn either from direct observations or from literature (Lo Valvo *et al.*, 1993). Feeding preferences of each species have been drawn from the available literature (Lo Valvo *et al.*,

1993) or from personal observations carried out in Sicily during the past twenty years. The benefit gained by each bird species from the presence of hedgerows has been evaluated directly during the censuses; the following uses have been distinguished: a) roosting site (e.g.: raptors); b) feeding site (on insects or berries); c) nesting site. We evaluated the benefit as scarce, moderate and high after the comparison of the species frequency on hedgerow-windbreaks and in the surrounding ecosystems and the information on vital functions performed by birds on hedgerows.

The comparison with other agroecosystems has been carried out using unpublished and published data (La Mantia and Massa, 1995; pers. obs.); it is limited to species breeding strictly in agroecosystems and which, for trophic reasons, can be detected in open fields (thus excluding birds breeding in marshlands, woods or over an altitude of 1000 m). Moreover birds whose trophic habitat is not easily detectable are not reported, even if they regularly occur in these habitats (e.g.: different species of raptors, Apodiformes *Apus* spp., House martin *Delichon urbica*, Pied and Grey wagtail *Motacilla alba* and *M. cinerea* and Tree sparrow *Passer montanus*). Stone-curlew *Burhinus oedipnemus*, Black-eared wheatear *Oenanthe hispanica* and Lesser grey Shrike *Lanius minor* have been excluded since they are considered as scarce or rare species in Sicily. However some rare breeding species such as Lanner Falcon *Falco biarmicus* and Roller *Coracias garrulus* were included because they strongly characterise the inland hilly habitats of the island.

RESULTS

A total of 45 bird species were detected more or less regularly on hedgerow-windbreaks, at least in one season of the year (Tab. 1). Twenty-six of them are sedentary species and utilise these strips of vegetation all through the year; ten of them visit the hedgerows only in the winter season (species usually not breeding in Sicily, but wintering with large populations); seven are only summer breeding and can be

detected only during the spring-summer season, afterwards migrating and wintering in Africa; two species were observed only during the migration period (spring or autumn) and we consider them as sporadic.

Fourteen species can be considered "scarce" (frequency less 25%); they live exclusively in particular habitats (wood or marshland) and only occasionally occur in the hedgerows (e.g. Blue tit *Parus caeruleus*, Short-toed Tree-creeper *Certhia brachydactyla*, Cetti's warbler *Cettia cetti*, etc.). Thirteen species resulted medium-scarce (frequency 26-50%), 12 medium-high (frequency 51-75%) and 6 highly frequent (frequency 76-100%).

As regards the trophic niche, out of 45 bird species, 13 resulted insectivorous, 20 insectivorous and baccivorous, carnivorous or granivorous, 4 exclusively carnivorous, 7 exclusively granivorous, 1 granivorous-baccivorous; 11 species resulted predators, feeding mainly on small vertebrates, although 6 of them completed their diet with insects, seeds and berries, particularly in certain seasons.

As far as benefit is concerned, 15 species gained benefit only from the hedgerow-windbreaks with trees and shrubs arranged in such a way as type b and c (see Material and Methods). Some species were seen to prefer particular species of trees (e.g.: Fringillidae which nest only on coniferous species). The benefit obtained from hedgerows can be considered high for 12 bird species, medium for 18 and scarce for the remaining 15 species (Tab. 1).

The analysis of the use of different habitats (hedgerow-windbreaks, open fields, olive grove, citrus grove) by birds revealed that the highest number of species breed in open habitats and hedgerow-windbreaks, performing many vital functions in these strips of vegetation (Tab. 2); in fact, 22 species occurred in hedgerows for breeding, 20 for feeding and 34 for roosting.

DISCUSSION AND CONCLUSIONS

Hedgerows, if correctly maintained, may increase biodiversity (Paoletti *et al.*, 1992), thanks

Tab. 1 - Relationships between different bird species and hedgerow-windbreaks in Sicily. Abbreviations: Season: 1-2 = reproductive season (spring-summer); 1-3 = migration period (spring-autumn); 1-4 = all through the year; 3-4 = wintering period (autumn-winter). Frequency of the species in the hedgerows: 1 = 25%; 2 = 26-50%; 3 = 51-75%; 4 = 76-100%. Diet: B = Berries; G = Grain; I = Insects; M = Meat. Vegetation: T = Trees; S = Shrubs; Con = Coniferous; BT = Big trees. Benefit obtained from hedgerows: H = High; M = Medium; S = Scarce.

SPECIES	SEASON	FREQUENCY	DIET	VEGETATION	BENEFIT
Buzzard <i>Buteo buteo</i>	1-4	2	M	BT	M
Lesser kestrel <i>Falco tinnunculus</i>	1-4	2	M-I	T	M
Lanner <i>Falco biarmicus</i>	3-4	1	M	T	S
Rock partridge* <i>Alectoris graeca</i>	1-4	1	I-G-B	S	S
Rock dove <i>Columba livia</i>	1-4	1	G	T	S
Woodpigeon <i>Columba palumbus</i>	1-4	3	G-B	T	H
Turtle dove <i>Streptopelia turtur</i>	1-2	2	G	T	M
Cuckoo <i>Cuculus canorus</i>	1-2	1	I	T	S
Barn owl <i>Tyto alba</i>	1-4	3	M	T	H
Scops owl <i>Otus scops</i>	1-4	3	M-I	T	H
Little owl <i>Athene noctua</i>	1-4	2	M-I	T	M
Short-eared owl <i>Asio flammeus</i>	1-3	1	M	T	S
Nightjar <i>Caprimulgus europaeus</i>	1-3	1	I	S	S
Hoopoe <i>Upupa epops</i>	1-2	2	I	T	M
Wryneck <i>Jynx torquilla</i>	3-4	1	I	T	S
Wren <i>Troglodytes troglodytes</i>	1-4	4	I	S-T	H
Dunnock <i>Prunella modularis</i>	3-4	2	I-B	S-T	S
Robin <i>Erithacus rubecula</i>	3-4	4	I-B	S-T	H
Nightingale <i>Luscinia megarhynchos</i>	1-2	3	I	S	H
Stonechat <i>Saxicola torquata</i>	1-4	3	I	S	M
Blackbird <i>Turdus merula</i>	1-4	4	I-B	S-T	H
Song thrush <i>Turdus philomelos</i>	3-4	1	I-B	S	S

(Continue)

Tab. 1 - (Continue)

SPECIES	SEASON	FREQUENCY	DIET	VEGETATION	BENEFIT
Cetti's warbler <i>Cettia cetti</i>	3-4	1	I-B	S	S
Subalpine warbler <i>Sylvia cantillans</i>	1-2	2	I-B	S	M
Sardinian warbler <i>Sylvia melanocephala</i>	1-4	4	I-B	S-T	H
Blackcap <i>Sylvia atricapilla</i>	1-4	3	I-B	T	H
Chiffchaff <i>Phylloscopus collybita</i>	3-4	2	I	T	M
Spotted flycatcher <i>Muscicapa striata</i>	1-2	2	I	T	M
Blue tit <i>Parus caeruleus</i>	1-4	1	I	T	S
Great tit <i>Parus major</i>	1-4	3	I	T	H
Short-toed treecreeper <i>Certhia brachydactyla</i>	1-4	1	I	T	S
Woodchat shrike <i>Lanius senator</i>	1-2	2	I	S-T	M
Jay <i>Garrulus glandarius</i>	1-4	1	M-I-B	T	S
Magpie <i>Pica pica</i>	1-4	4	M-I-B-G	T	H
Hooded crow <i>Corvus corone</i>	1-4	2	M-I-B-G	T	M
Starling <i>Sturnus vulgaris</i>	3-4	1	I-B-G	T	S
Spotless starling <i>Sturnus unicolor</i>	3-4	1	I-B-G	T	S
Spanish sparrow <i>Passer hispaniolensis</i>	1-4	3	I-G	T	M
Chaffinch <i>Fringilla coelebs</i>	3-4	2	G	T	M
Serín <i>Serinus serinus</i>	1-4	4	G	Con	H
Greenfinch <i>Carduelis chloris</i>	1-4	2	G	Con	M
Goldfinch <i>Carduelis carduelis</i>	1-4	3	G	Con	M
Linnet <i>Carduelis cannabina</i>	1-4	3	G	Con	M
Cirl bunting <i>Emberiza cirlus</i>	1-4	3	I-G	S	M
Corn bunting* <i>Miliaria calandra</i>	1-4	3	I-G	S	M

*: species nesting on the ground, often sheltered by hedgerow /shrubs.

Tab. 2 - Utilisation of different agroecosystems by some species of birds breeding in Sicily.
 Feed: feeding use; NR: night roost or irregular shelter; Repr: reproductive habitat; Roost: roost for hunting, singing or other functions.

SPECIES	HABITAT			
	HEDGEROW-WINDBREAK (SEE TAB. 1)	OPEN FIELDS WITHOUT HEDGEROWS	OLIVE GROVE	CITRUS GROVE
Buzzard				
<i>Buteo buteo</i>	REPR-ROOST	FEED	REPR-FEED-NR	
Kestrel				
<i>Falco tinnunculus</i>	ROOST	FEED	REPR ¹ -FEED-NR	
Lanner				
<i>Falco biarmicus</i>	ROOST	FEED		
Rock partridge				
<i>Alectoris graeca</i>	REPR ²	REPR-FEED		
Quail				
<i>Coturnix coturnix</i>		REPR-FEED		
Rock dove				
<i>Columba livia</i>	NR	FEED		
Wood pigeon				
<i>Columba palumbus</i>	REPR-ROOST-NR	FEED	REPR-FEED-NR	
Turtle dove				
<i>Streptopelia turtur</i>	REPR-ROOST	FEED	REPR-FEED-NR	
Barn owl				
<i>Tyto alba</i>	ROOST-NR	REPR ³ -FEED	FEED-NR	
Scops owl				
<i>Otus scops</i>	REPR-ROOST-NR	FEED	REPR-FEED-NR	
Little owl				
<i>Athene noctua</i>	ROOST-NR	REPR ⁴ -FEED	REPR-FEED-NR	
Roller				
<i>Coracias garrulus</i>	ROOST	FEED ⁵		
Hoopoe				
<i>Upupa epops</i>	REPR-ROOST	FEED	REPR-FEED	
Calandra lark				
<i>Melanocorypha calandra</i>		REPR-FEED		
Short-toed lark				
<i>Calandrella brachydactyla</i>		REPR-FEED		
Crested lark				
<i>Galerida cristata</i>		REPR-FEED		
Woodlark				
<i>Lullula arborea</i>		FEED		
Swallow				
<i>Hirundo rustica</i>		FEED		
Tawny pipit				
<i>Anthus campestris</i>		REPR-FEED		
Wren				
<i>Troglodytes troglodytes</i>	REPR-FEED-ROOST-NR	FEED	REPR-FEED	REPR-FEED
Nightingale				
<i>Luscinia megarhynchos</i>	REPR-FEED-ROOST			
Stonechat				
<i>Saxicola torquata</i>	ROOST-NR	FEED	Λ	
Wheatear				
<i>Oenanthe oenanthe</i>		REPR ⁶ -FEED		
Blackbird				
<i>Turdus merula</i>	REPR-FEED-ROOST-NR	FEED	REPR-FEED	REPR-FEED
Cetti's warbler				
<i>Cettia cetti</i>	ROOST-FEED-NR			
Fan-tailed warbler				
<i>Cisticola juncidis</i>		REPR-FEED		

(Continue)

Tab. 2 - (Continue)

SPECIES	HABITAT			
	HEDGEROW-WINDBREAK (SEE TAB. 1)	OPEN FIELDS WITHOUT HEDGEROWS	OLIVE GROVE	CITRUS GROVE
Spectacled warbler	ROOST	REPR ² -FEED		
<i>Sylvia conspicillata</i>				
Subalpine warbler				
<i>Sylvia cantillans</i>	REPR-FEED-ROOST-NR	REPR ² -FEED	FEED	
Sardinian warbler				
<i>Sylvia melanocephala</i>	REPR-FEED-ROOST-NR	FEED	REPR-FEED-NR	FEED
Blackcap				
<i>Sylvia atricapilla</i>	REPR-FEED-ROOST-NR	FEED	FEED	REPR-FEED
Spotted flycatcher				
<i>Muscicapa striata</i>	ROOST	FEED	REPR ¹ -FEED-NR	REPR-FEED-ROOST
Blue tit				
<i>Parus caeruleus</i>	FEED-ROOST		FEED	
Great tit				
<i>Parus major</i>	REPR-FEED-ROOST		REPR-FEED-ROOST	REPR-FEED
Short-toed treecreeper				
<i>Certhia brachydactyla</i>	FEED		REPR-FEED	
Woodchat shrike				
<i>Lanius senator</i>	REPR-ROOST	FEED	REPR-FEED-ROOST	
Jay				
<i>Garrulus glandarius</i>	FEED-ROOST-NR		REPR ¹ -FEED-ROOST	
Maggpie				
<i>Pica pica</i>	REPR-FEED-ROOST-NR	FEED	REPR-FEED-ROOST-NR	FEED
Hooded crow				
<i>Corvus corone</i>	ROOST	FEED	REPR-FEED-ROOST	
Jackdaw				
<i>Corvus monedula</i>		FEED	FEED	
Spotless starling				
<i>Sturnus unicolor</i>	FEED-ROOST-NR	FEED	FEED	
Spanish sparrow				
<i>Passer hispaniolensis</i>	REPR-FEED-ROOST-NR	FEED	REPR ¹ -FEED	FEED
Chaffinch				
<i>Fringilla coelebs</i>	FEED-NR	FEED	FEED	REPR-FEED
Serin				
<i>Serinus serinus</i>	REPR-FEED-ROOST	FEED	REPR ¹	REPR-FEED
Greenfinch				
<i>Carduelis chloris</i>	REPR-FEED-ROOST-NR	FEED	ROOST	REPR-FEED
Goldfinch				
<i>Carduelis carduelis</i>	REPR-FEED-ROOST-NR	FEED	REPR ¹	REPR-FEED
Linnet				
<i>Carduelis cannabina</i>	REPR-FEED-ROOST-NR	FEED		REPR-FEED
Cirl bunting				
<i>Emberiza cirlus</i>	REPR-FEED-ROOST-NR	FEED	FEED	
Corn bunting				
<i>Miliaria calandra</i>	REPR ² -ROOST	REPR-FEED	FEED	
Repr	22 (2 ²)	13 (1 ³ ; 1 ⁴ ; 1 ⁵ ; 1 ⁶ ; 2 ²)	20 (6 ¹)	10
Feed	20	42	27	13
Roost	34		6	1
NR	21		10	
TOTAL	38	42	30	13

1: sporadic functions; 2: species nesting on the ground under shrubs; 3: species nesting in old buildings; 4: species nesting on dry stone walls or heaps; 5: species nesting on dry stone walls or stone bridges or holes in trees; 6: species nesting on dry stone walls; 7: species nesting in open field, on shrubs even if isolated.

also to a complex effect called "edge effect", which causes a qualitative and quantitative increase of wildlife (Park, 1988) as consequence of a "synergistic phenomenon", namely the effect brought about by the contact of the edges of two habitats (known as *ecotone*) with characteristics different from the simple addition or combination of them (Frochot, 1987).

Classification of birds based on their diet suggests that hedgerow-windbreaks are mostly utilised by insectivorous species (Tab. 1). Many authors have stressed the importance of insect predation by insectivorous birds in hedgerows (cf. La Mantia and Massa, 1995, and references herein). Ferber (1974) estimated the amount of insects preyed upon by birds in hedgerows to be as much as 148 kg year⁻¹ for one km length. Insect predation is carried out in areas adjoining the hedgerows and in the hedgerows themselves, in particular when they are located in warm regions and at the border of open fields; in this case they become a rich supply of arthropods. Many bird species, although granivorous in winter, become insectivorous in spring-summer (e.g. Chaffinch, *Fringilla coelebs*), their young requiring the assumption of animal proteins to grow. Some studies revealed that a positive relationship exists between insect abundance in the diet and the survival probability of young and demonstrated that the growth of chicks largely depends on the presence of sulphur aminoacids such as cystine and methionine, contained in higher amounts in insects than in plants (up to four times higher in insects than in wheat: Hudson and Rands, 1988).

In Mediterranean regions, hedgerows are an important supply of food not only for sedentary birds but also for huge numbers of migratory and wintering species, since a mild winter allows a plentiful supply of berries and insects during the winter months. Many birds take advantage not only of insect populations, but also of the peak of berry production of some shrubs that in south Mediterranean regions occurs two months later than in central Europe (Herrera, 1982; Snow and Snow, 1988). Indeed in October-January we observed insectivorous birds (e.g. some Sylviidae and Tur-

dididae), both sedentary and wintering, often feeding on berries of shrubby plants, taking advantage of this important source of energy.

The presence of trees, even when isolated, is sufficient to increase bird diversity; shrubs increase the naturalistic value of hedgerows, by creating a cover under tree foliage that increases their total width. Hedgerow width is an important parameter for nest density, bird diversity and successful reproduction (Shalaway, 1985); it affects the density of species such as Woodchat shrike *Lanius senator*, Blackbird *Turdus merula*, different Sylviidae and other species (e.g.: Cirl bunting *Emberiza cirrus*, some Sylviidae) which feed in open habitats but breed on small shrubs or use them as singing perches. This linear habitat, being like an island in the middle of large unsuitable ecosystems, may represent the only reproductive site for some species; breeding of Fringillidae occurs mostly on coniferous species, and the presence of these trees, even if isolated within broadleaved species, permits their populations to maintain, especially in open-field agroecosystems, their winter foraging habitat. Hedgerows thus enable the main habitat (often an open habitat) to be utilised to the full with respect to many important functions.

The prevailing presence of insectivorous birds in hedgerows confirms the importance of these elements for bird feeding, as well as the importance of hedgerows for the surrounding habitats. The choice of plant species is not a secondary aspect in hedgerow-windbreak planning. An important aspect to be considered is the possibility offered by certain shrubby plants of becoming a relevant source of food, such as berries for many Turdidae (Song thrush *Turdus philomelos* and Blackbird *Turdus merula*), some Sylviidae and other baccivorous species. These species derive benefit from several shrubs, namely *Myrtus communis*, *Sambucus nigra*, *Rhamnus alaternus*, *Pistacia lentiscus*, *Lonicera implexa*, but also from tree species such as *Celtis australis*, *Crataegus azarolus*, *Laurus nobilis*, *Mespilus germanica*, *Olea europaea*, *Pistacia terebinthus*, *Phillyrea media* and *angustifolia*, *Sorbus domestica*, *Pyrus pyraster* and *amygdaliformis*. Their diffusion in the implan-

tation of new Mediterranean hedgerow-windbreaks should be encouraged; it would be preferable to use trees and shrubs alternatively, choosing some evergreen plants which produce fruits during the winter. This is certainly possible in a Mediterranean region up to an altitude of 1000 m. Hedgerows of such a nature might interrupt landscape monotony, increase the faunistic diversity and also increase the predation of insects by birds and insectivorous mammals.

Some authors (e.g. Dennis *et al.*, 1994; Thomas *et al.*, 1991) pointed out the importance of field boundaries, hedgerows and windbreaks as alternative habitats which could improve the biology and dynamics of beneficial insects; thus they should be regarded as important components of agroecosystems. Results of the present research have shown the beneficial effects of these linear habitats to birds species; most of them are insectivorous but we believe that for the following reasons they cannot influence populations of these insects to any great extent, while they are more interested in phytofagous species: 1) beneficial insects (predators, such as Coleoptera Carabidae and Staphylinidae) have chiefly nocturnal habits and spend their day time within shelters under logs and stones in the soil; 2) their populations generally are numerically scarce, whereas those of phytophagous species are often very abundant, thus the probability that birds prey upon beneficial insects is very low with respect to phytophagous predation; 3) many phytophagous insects, feeding directly on the phloem of plants, are rich in sugars, which in turn are very efficiently assimilated by predators and converted to fat.

Although planting of different plant species contributes to the increase of wildlife diversity, hedgerows are almost exclusively planned for a windbreak function and thus often consist of a single row of trees.

The biological importance of hedgerows for birds depends also upon a warmer climate in respect to the surrounding open areas, which preserves them from any dangerous thermic fluctuation. A strategic orientation, that maximizes exposition to the sun and protection

from winds during the winter, enables hedgerows to provide thermoregulatory benefits to animal species living there.

Hedgerow-windbreaks, shrubs and trees, isolated, in rows or in small woods, are an integrant part of the agricultural landscape, strongly influencing all its environmental components (Forman and Godron, 1986; Barrett, 1992); their "maintenance or restoration" is a fundamental aspect of landscape planning (Fabbri, 1993; Genghini, 1994).

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