

# EMPIRICAL PROCEDURES TO IDENTIFY MIGRATORY BIRD BOTTLENECKS IN THE ALPINE AREA

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## ABSTRACT

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Mountain crossings are critical sites for the conservation of migratory species. In order to identify which ones do represent bottlenecks in the Alpine area of Lombardy in the course of autumn migration, we selected five different data sources:

1. the location of 981 recoveries of birds ringed abroad during the same autumn migration,
2. the shortest possible route followed by 313 birds ringed and recovered within the region during the same autumn migration,
3. the average number of birds ringed per year in the regional ringing stations,
4. the location of 429 former traditional netting sites,
5. the number and density of bird hunting hides per municipality.

Data were gathered using the Geographical Information System. An overlay with a regional elevation coverage allowed to identify 27 most relevant mountain crossings. Two major migratory routes could be identified: NE and NW. The first one is equally used by most of the species, while the second one seems to be typical for finches. The highest number of important crossings was found in the central part of southern Alps, where the two migratory flows intersect. Most of those crossings lie at elevations between 900 and 1300 m a.s.l.

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## INTRODUCTION

The conservation of migratory birds is related to the measures taken in several places of high bird concentration, according to their migration routes (Biber and Salathé 1991). In Italy, and in particular in its northern part (where Lombardy is located), bottlenecks may be found in the Alpine area (*i.e.* Spanò *et al.* 1996). Among about 380 bird species found in Lombardy, only 10 are strictly resident, while all

others are subjected to different kind of migration movements (Brichetti and Cambi 1987, Fornasari *et al.* 1992).

In Europe, bird migration movements show apparently a general pattern from the north-east to the south-west during the autumn migration and an opposite one during the spring migration. These patterns are thought to be based on the orientation of the European continent and the presence, in its western part, of many peninsulas influenced by the Atlantic or Mediterranean climate (Mead 1983). However, Busse (1987, 2000) presents more complicated migration pattern and stresses a role of Ice-Age refuges in development of migratory behaviour of birds in Europe. Due to the species, autumn movements take place from August to November, while spring movements – from February to May. Therefore, migration movements occur eight months a year.

In Lombardy, hunting activities are allowed only during the autumn migration (not during the spring migration) in order to protect bird population. Within Lombardy, autumn migration movements involve (Schubert *et al.* 1986):

1. bird populations breeding in northern Eurasia and wintering in Lombardy,
2. bird populations breeding in Lombardy and wintering in different parts of the region or in the nearby regions,
3. bird populations breeding in Lombardy and wintering around the Mediterranean basin,
4. bird populations breeding in northern Eurasia and wintering around the Mediterranean basin,
5. bird populations breeding in Lombardy and wintering south of the Sahara;
6. bird populations breeding in northern Eurasia and wintering south of the Sahara.

All these categories may use mountain passes during their migration, but categories (1), (4) and (6) probably use them more than the others.

Bird migration occurs during the night for transsaharian migrants, during the day – for birds that migrate short or medium distances. Nocturnal migrants usually fly at the altitude around 1000 m, while diurnal – at the lower altitude (Bruderer and Jenny 1990). The latter are the group most likely found close by the mountain passes.

Moreau (1972) estimated, for the whole western Palaearctic, a total number of trans-saharian migrating passerine as 5 billions individuals. By simple using a ratio of the number of birds to the width of migration front, we can roughly estimate a minimal number of 300 millions of trans-saharian passerines flying over Lombardy during the autumn migration. The huge amount of passerine birds involved in this migration can also be estimated on the basis of the consistence of wintering populations (see Fornasari *et al.* 1992). Considering this migration volume, an evaluation of the role played by the bottlenecks appears to be very important for the conservation purposes, especially because the Italian National Law 157/92 prohibits any game activity in a radius of 1000 m from any mountain pass significantly used by birds during migration. According to the national wildlife service – INFS (Istituto Nazionale per la Fauna Selvatica), a mountain pass acting as a birds bottle-

neck is defined as any „depression situated along a mountain ridge that makes easier birds crossing”. In addition, the Italian National Law 1102/71 indicates that for the bottleneck protection, these depressions should be situated above 600 m a.s.l.

## STUDY AREA AND METHODS

Our study area corresponds to the whole administrative region of Lombardy. The region (over 23 842 sq. km) is located in the northern part of Italy and may be divided into four main geomorphologic areas:

1. an Alpine area in the north, characterised by high average elevations – several mountain tops over 3000 m a. s. l. (maximal height – 4055 m a. s. l.) – and glacial or cold climate;
2. a hilly and mountainous area, characterised by lower elevations and cold temperate climate;
3. a lowland area, located in the Po valley, characterised by low elevations (minimal height – 8 m a. s. l.) and sub-continental temperate climate;
4. an Apennine area, located in the southern part of the region and characterised by hilly landscape and sub-continental temperate climate.

Except for the Alpine area and the places located at the highest elevations in other areas, the whole region is heavily populated (average for the region – 565 people/sq. km). Three Alpine ridges are present (see also Fig. 1): Lepontine (on western border), Retiche (on northern border, to western edge of the region), Orobie (south of the Retiche, to western edge of the region). Lepontine and Retiche are separated by the depression of Val Chiavenna, Lepontine and Orobie by the Como Lake, Retiche and Orobie by the depression of Valtellina.

In order to identify mountain passes that act as bird migration bottlenecks, indirect methods may be used instead of direct counting. Following the guidelines suggested by INFS (unpubl. report), we analysed data concerning:

1. the location of recoveries of birds ringed abroad during the autumn migration,
2. the shortest possible route followed by birds ringed and recovered within the region during the autumn migration;
3. the average number of birds ringed per year in the regional ringing stations;
4. the location of former traditional netting sites;
5. the number and density of bird hunting hides per municipality.

All these data were analysed together with elevation data by means of the Geographical Information System (Arc View 3.0a).

Regarding point (1), a set of 981 data was analysed. These data were provided by INFS (unpubl. data) and concerned the location of recoveries of 15 species of passerine and 3 species of raptors as indicated in Table 1. Regarding point (2), data collected by the regional ringing stations from 1977 to 1995 were analysed (Vigorita and Reguzzoni 1996). These referred to 27 species of passerine and 4 non-passerine for a total number of 313 locations (Table 1). Furthermore, the average number of birds from 29 selected species ringed at 31 regional ringing stations from 1977 to



Fig. 1. Study area. The main mountain ridges and alpine valleys are shown.

1995, was used for point (3) (Vigorita and Reguzzoni 1996). Species selection was made considering all of the game species, all of the abundant species, and all of the species pertaining to the same families as those found in point (1) and (2) (see Table 1). For point (4), we used the location of 429 former traditional netting sites, established for bird hunting since the 16<sup>th</sup> century (Bassini 1958). They were important as birds were a source of animal protein in the traditional rural economy and they stopped their activity only several decades ago. Mora (1985) provided information about these sites in the Bergamo Province. Information of the sites in the Brescia Province were provided by its public administration. Additional information of the other provinces were collected interviewing people and examining the toponymy found on the national maps scale 1 : 25 000. For point (5), 13 326 hunting hides in 1493 municipalities were identified – data were provided by the public administration of provinces concerned.

Two main rules were followed in order to identify bird bottlenecks:

1. The ridge crossed should be almost perpendicular to the main migratory flow.
2. The mountain pass might lie on the shortest route between consecutive areas of migratory birds concentration.

Table 1  
Data used for the identification of the major bottlenecks for bird migration  
across the Alps of Lombardy

	Recoveries from abroad	Recoveries within the region	Birds ringed in Lombardy
<i>Circus aeruginosus</i>	3	-	-
<i>Buteo buteo</i>	1	-	-
<i>Falco tinnunculus</i>	10	-	-
<i>Accipiter nisus</i>	-	1	-
<i>Coturnix coturnix</i>	-	-	62 (0.01%)
<i>Scolopax rusticola</i>	-	1	41 (0.01%)
<i>Strix aluco</i>	-	1	-
<i>Streptopelia turtur</i>	-	-	24 (0.00%)
<i>Jynx torquilla</i>	-	1	-
<i>Alauda arvensis</i>	-	1	3 062 (0.43%)
<i>Anthus trivialis</i>	-	14	44 717 (6.28%)
<i>Prunella modularis</i>	-	4	14 253 (2.00%)
<i>Erithacus rubecula</i>	67	21	58 898 (8.27%)
<i>Phoenicurus phoenicurus</i>	-	-	4 220 (0.59%)
<i>Turdus merula</i>	23	32	25 586 (3.59%)
<i>Turdus pilaris</i>	83	17	9 815 (1.38%)
<i>Turdus philomelos</i>	52	50	74 869 (10.51%)
<i>Turdus iliacus</i>	43	43	25 901 (3.64%)
<i>Turdus viscivorus</i>	-	1	850 (0.12%)
<i>Sylvia borin</i>	19	-	7 015 (0.98%)
<i>Sylvia atricapilla</i>	19	5	25 861 (3.63%)
<i>Phylloscopus collybita</i>	-	1	-
<i>Muscicapa striata</i>	-	-	2 707 (0.38%)
<i>Ficedula hypoleuca</i>	92	-	22 877 (3.21%)
<i>Parus montanus</i>	-	1	-
<i>Parus ater</i>	-	2	-
<i>Parus caeruleus</i>	-	1	-
<i>Parus major</i>	-	7	-
<i>Sitta europaea</i>	-	1	-
<i>Certhia brachydactyla</i>	-	2	-
<i>Lanius collurio</i>	-	-	445 (0.06%)

<i>Sturnus vulgaris</i>	156	6	6 802 (0.95%)
<i>Passer domesticus x italiae</i>	-	3	-
<i>Passer montanus</i>	-	3	-
<i>Fringilla coelebs</i>	29	15	131 569 (18.48%)
<i>Fringilla montifringilla</i>	108	11	65 350 (9.18%)
<i>Serinus citrinella</i>	-	-	2 398 (0.34%)
<i>Serinus serinus</i>	-	1	-
<i>Carduelis chloris</i>	-	3	11 344 (1.59%)
<i>Carduelis carduelis</i>	-	-	3 119 (0.44%)
<i>Carduelis spinus</i>	134	23	66 828 (9.39%)
<i>Carduelis cannabina</i>	-	13	-
<i>Loxia curvirostra</i>	30	-	10 054 (1.41%)
<i>Pyrrhula pyrrhula</i>	-	-	2 281 (0.32%)
<i>C. coccythraustes</i>	28	28	24 746 (3.47%)
<i>Emberiza schoeniclus</i>	84	-	1 841 (0.26%)

## RESULTS AND DISCUSSION

### General pattern

Finches and thrushes dominated in both samples of recoveries from abroad and from other places within the region (Table 1). Location of the recoveries of birds ringed abroad clearly show high density of sites in the pre-alpine area, particularly at the exit of the main valleys (Fig. 2). Two general bird migration routes could be identified: the first one located in eastern part of the region that enters Lombardy from the adjacent Trentino region, and the second one, entering the region in north-western part and coming from Switzerland through the Splügen Pass. This second route appeared to be the most important for finches. These species are diurnal migrants and fly at low altitudes using the mountain passes in order to cross the mountain ridges. The recoveries of thrushes and small insectivorous birds – such as the Robin (*Erithacus rubecula*), the Blackcap (*Sylvia atricapilla*), the Garden Warbler (*Sylvia borin*) and the Pied Flycatcher (*Ficedula hypoleuca*) – did not suggest any preferred migration route. These species are nocturnal migrants and usually fly at high altitudes so that they are rarely recovered in mountain passes or valleys. Recoveries of birds ringed within the region highlight how migratory birds tend to avoid the high mountain of Orobie and follow other directions: in Valtellina, we only found winter recoveries of birds ringed in the south during the same migratory season –the Blackbird (*Turdus merula*) and the Fieldfare (*Turdus pilaris*). The two migration routes intersect in southern side of the Orobian Alps. In addition, most

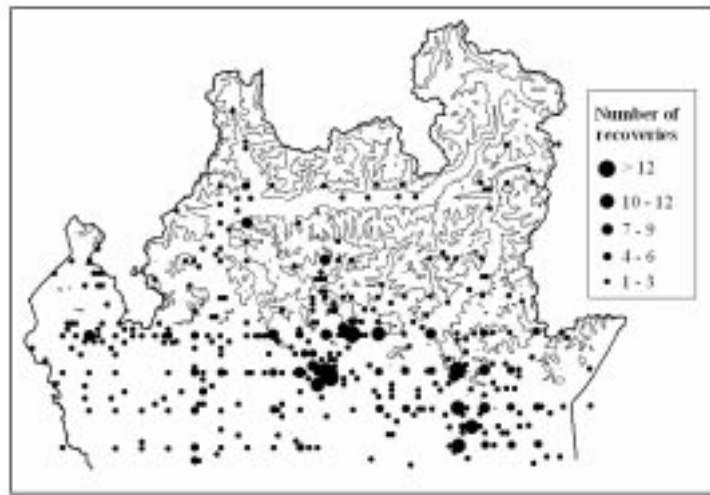


Fig. 2. Distribution of the recoveries of birds ringed abroad.

recoveries of birds ringed in the region indicate that several species perform horizontal movements during autumn but they winter south of the pre-alps, even though some recoveries indicate straight flyways from north to south (Fig. 3).

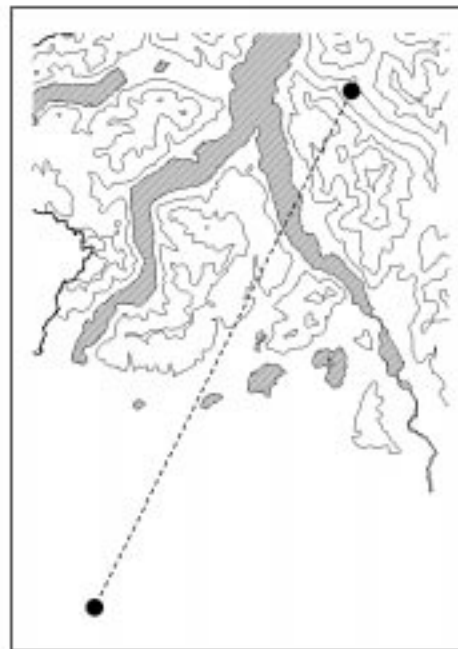


Fig. 3. Detail of the shortest possible way between ringing and recovering sites of the Linnet in autumn migration across Lombardy.

### Identification of migration routes

In northern part of the region, the low number of data seems to indicate that few birds, at least some unusual species such as the Kestrel (*Falco tinnunculus*), may arrive at Valtellina, going through the Retiche Alps and some minor valleys showing an orientation N-S or NE-SW across ridges with very high altitude (over 4000 m at the Bernina peak). No important passes were identified in this section of the Alps.

The two small clusters of recovery sites suggest two main entrances to the region, through the Splügen Pass on the western side, and the Tonale Pass on the eastern side. In fact, high densities of recoveries are located east of Lake Como on western migration route, and in Val Camonica on eastern migration route.

In eastern part of the region, the main flow through the major valleys is much more obvious. The way, in which birds may spread over the region is suggested by a high concentration of traditional netting sites along Val Camonica, Val Trompia, Valvestino and Val Sabbia, oriented NE to SW. A very high number of hunting hides and long-distance recoveries were found in Val Trompia. The presence of some netting sites at unusual elevations indicates several links among these main streams.

In western side of the region birds coming from the Splügen Pass fly along Val Chiavenna moving at a low elevation around the border of the Lepontine Alps ridge, or at a high elevation through a pass (Bocchetta di Chiaro – 1660 m a. s. l.) facing on Lake Como, where two of us (unpubl. data) counted thousand of finches per day around the migration peak in the early days of October. Afterwards, the birds involved respectively (a) fly south along Lake Como, or (b) fly through the Orobie Alps following a straight line of passes going south-east, in direction of Val Brembana.

Recoveries of birds in western part of the region might indicate that the third (minor) migration route may enter Italy from Switzerland along Valganna in the Varese Province, with its possible bottlenecks being located somewhere in Switzerland.

The two main migration routes intersect over Valseriana, on southern side of the Orobie Alps, where traditional netting sites, hunting hides and recoveries of birds show very high densities. In this area, the number of ringed birds per site per year is also high.

### Bottlenecks overview

Our results underline the possibility of drawing a general picture of the migration pattern throughout an entire region based only on an empirical procedure. The overall analysis of the data suggests the existence of 27 significant bird bottlenecks (Fig. 4). Four of them could be addressed as „alpine” bottlenecks (Splügen Pass, Passo di San Marco, Passo del Vivione, Tonale Pass), most of the other are situated at lower elevations (900-1300 m a. s. l.). Bottlenecks at elevations higher than 1800 m are more frequent along the eastern migration route (see Table 2).



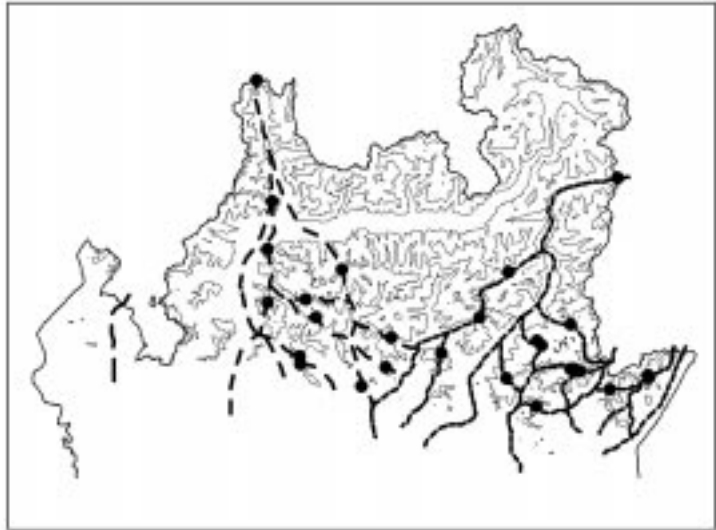


Fig. 4. General pattern of migration routes and significant bottlenecks inferred through the available data.

Table 2

List of the significant bottlenecks identified within the region (see also Fig. 4). Provinces:  
BG – Bergamo, BS – Brescia, CO – Como, LC – Lecco, SO - Sondrio

Bottlenecks	Elevation	Province	East	North
Tonale Pass	1883	BS	622030	5124184
Sella di Mandro	736	BS	600190	5063029
Passo delle Portole	1726	BS	609300	5073084
Passo della Berga	1522	BS	610255	5073029
Passo della Spina	1521	BS	611845	5072249
Monte Crestoso	2059	BS	601755	5079209
Monte Frà	2100	BS	600600	5080529
Foppella di Colle San Zeno	1410	BS	592230	5070404
Passo della Puria	1372	BS	630040	5071364
Passo Scarpapè	1242	BS	630115	5070714
Valico di Capovalle	957	BS	619775	5067509
Passo di Crocedomini	1859	BS	609415	5084924
Passo del Vivione	1828	BG-BS	592880	5099034
Giogo della Presolana	1297	BG-BS	585120	5086929
Valico Campo d'Avena	1307	BG	574735	5076154
Splügen Pass	2115	SO	525415	5150469
Bocchetta di Chiaro	1660	CO	529455	5117914

Roccoli dei Lorla	1426	LC	528565	5105089
Bocca di Prada	1634	LC	528195	5091029
Passo del Pertus	1183	LC-BG	537145	5074159
Passata	1244	LC-BG	536915	5076404
Forcella d'Artavaggio	1560	LC-BG	541455	5086879
Passo del Cedrino	1661	LC-BG	538525	5091539
Passo San Marco	1985	SO-BG	548225	5099669
Valico del Canto Basso	901	BG	553510	5068269
Passo della Crocetta	1267	BG	561465	5081344
Forcella	1218	BG	559880	5073469

The high number of recoveries, former netting sites and hunting hides indicate that attention must be paid especially to those bottlenecks located in the central part of the region, where eastern and western migratory routes intersect. From an administrative point of view, it may be noted that most bottlenecks are concentrated within two provinces, while alpine part of the region is subdivided into 5 provinces and the whole region in 11 provinces (Table 2). The Brescia Province holds 14 bottlenecks, while the Bergamo Province holds as much as 10 bottlenecks over an area that covers only 11% of the region. These two administrative units also show a very high hunters density. As the mountain passes identified as bottlenecks should obviously be subjected to some kind of protection, this situation may also create conflicts at the level of decision-makers. It is hoped that they will be able to solve this problem wisely.

Table 3

Area, number of bottlenecks and number of hunters per province in Lombardy (in brackets: the number of bottlenecks shared with another bordering province).

Province	Area	Hunters	Bottlenecks
Bergamo	2 771 sq.km (11.6%)	15 851	10 (7)
Brescia	4 784 sq.km (20.0%)	30 814	14 (2)
Como	1 251 sq.km ( 5.2%)	4 327	1
Lecco	816 sq.km ( 3.4%)	3 815	6 (4)
Sondrio	3 212 sq.km (13.5%)	2 698	2 (1)
Other (six)	11 038 sq.km (46.2%)	40 411	0

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