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The Dipper *Cinclus cinclus* in Sicily

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Abstract -. The distribution and density of the Dipper (*Cinclus cinclus*) in Sicily has been studied from existing records over the main island's catchments. The species has been decreasing in number over the past 40 years and it is now restricted to a few , isolated and residual montane areas and can be considered on the verge of extinction. Mean density in these areas (6.3 pairs/10 kms) matches the mean values reported for continental Europe, but the decrease in range and the isolation of the populations follow the progressive drying and transformation undergone by the Sicilian basins as a result of anthropogenic and metereological factors. The Dipper's presence is strongly tied to permanent streams, but its density, assessed by multiple regression analysis, is related to stream bed morphology: gradient, substrate granulometry, water temperature and depth. The species breeds along stretches of high quality water where, according to the E.B.I. method, the fauna is richer in macroinvertebrate than elsewhere.

Introduction

In the past few decades, owing to progressive human intervention, the natural environment of Sicily has undergone large changes in its characteristics and appearance. In this regard, some stenotropic (i.e. organisms exhibiting a limited response of adaptation to changing environmental conditions; Lincoln et al. 1990) riverine species sensitive to the altered environment, act as ecological indicators.

Lotic ecosystems represent one of the Sicilian environments recently affected by heavy anthropogenic pressure. River embankment works, canalisation building of artificial dams and basins, groundwater capture and collection, are all responsible for the drying up or radical transformation of the majority of Sicilian streams. The prolonged drought of the past few years (1987-1990) has on one hand caused the natural drying up of several torrents, while on the other increased the consumption of water. In this context, the Dipper (*Cinclus cinclus*) can play a crucial role both as an ecological indicator of the quality of the lotic ecosystems still in existence, and as a species in great danger of extinction along with the aquatic community it represents. With this view in mind, we present the preliminary results of research, started in 1987, on the Dipper's distribution and ecology across the island.

Material and Methods

Data and information on the captures and habits of the Dipper in Sicily since the second half of the last century, were obtained from library and museum records. Some historical texts reported breeding in some areas, whereas breeding from the museum records was judged by the date of capture. The historical research checked all the main texts and sicilian collections and the resulting past Dipper distribution can be considered quite exhaustive even if some information has been lost (i.e. specimens in Italian and foreign museums and few specimens without data in Sicilian collections).

Thirty field excursions in some of the main Sicilian catchment basins, where the species was formerly recorded, were carried out to check for the presence and breeding of the species, in line with the European Ornithological Atlas Committee code (A=possible; B=probable; C=certain breeding), and thus update the Regional Atlas (UTM grid;10kms per side) distribution data for the 1979-1983 period (Priolo in Massa 1985). With the aim of determining the population density of the species in some sample areas, 41 additional field trips were repeated in different months (from April to July and October-November) of the years 1988-90 in 7 streams, in the Nebrodi mountains of North-Eastern Sicily (Rosmarino, Scavioli, San Barbaro, San Fratello, Milè, San Pietro) and the Sicani mountains in MidWestern Sicily (Sosio river).

The duration of each trip was timed, excluding pauses; this enabled us to estimate the relative contact frequency (n of contacts/trip duration in min) and the number of individuals. The number of nest-building pairs was estimated along some of the torrents by searching for nests and "doubling back" method

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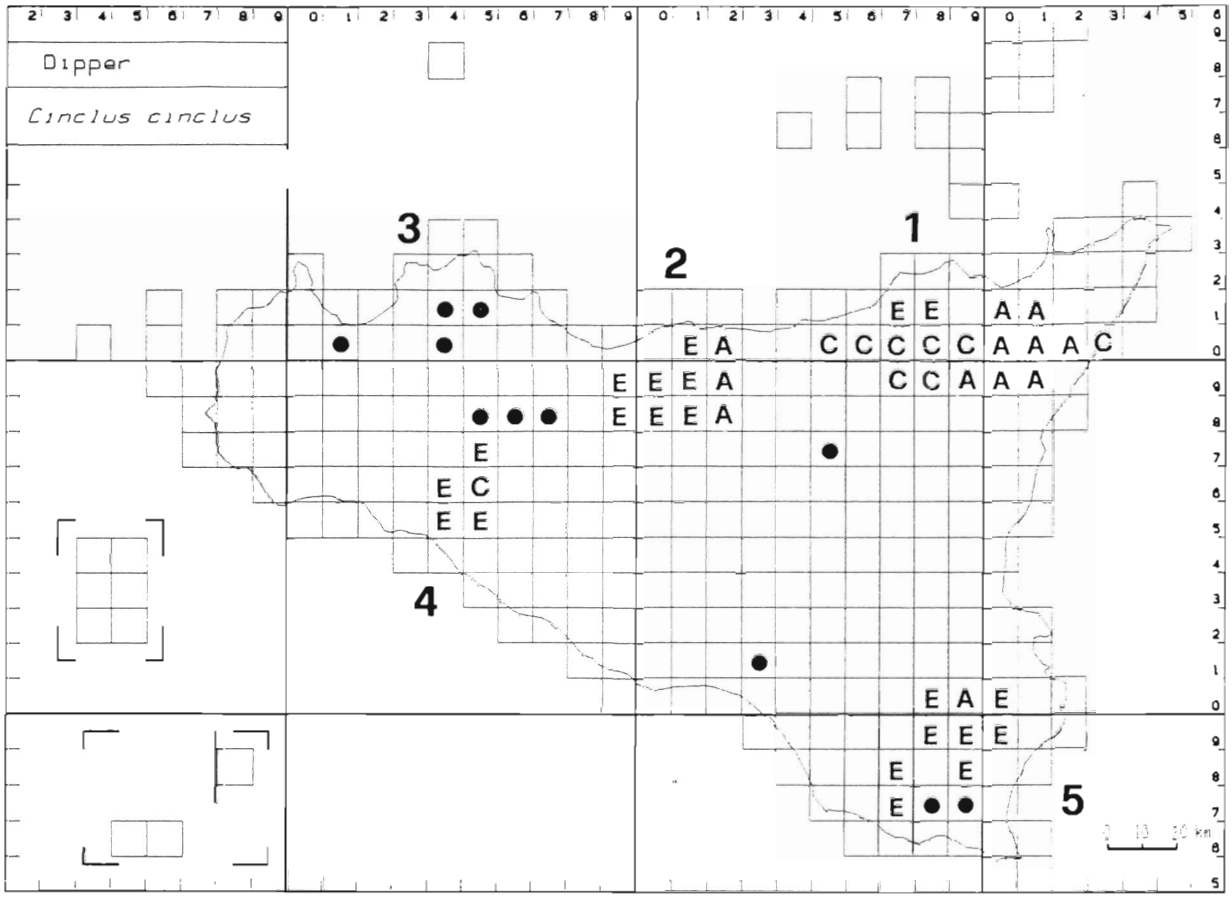

Figure 1 - Distribution of Dipper (*Cinclus cinclus*) in Sicily on an U.T.M. grid (10 kms per square). C = certain breeding, A = possible breeding; E = extinct within the period 1950-90, black dots = past records of presence and/or breeding before 1950. Dipper absence was checked and confirmed in the squares marked with E and black dots during the research. 1-5 regions cited in text; 1 = Caronie and Peloritani; 2 = Madonie; 3 = Conca d'Oro; 4 = Sicani; 5= Iblei.

(Balat, 1962); in that individuals occupy linear territories and at their borders change flight direction so as to remain within their own home range.

The physical features of each stream were monitored and recorded at the same stations in different months. Water temperature, pH and dissolved O_2 were measured with portable instruments; a mean of 7,6 ± 4,9 samples of temperature, pH and O_2 were recorded per excursion. Samples of aquatic macroinvertebrates, taken by one of us (Gi.Sa.) at two fixed stations (up and downstream) in 5 streams, according to the standard E.B).I. methods (Woodwiss 1978, Ghetti 1986), have enabled us to assess the water quality of stretches of these streams. By the use of multiple regression analysis (MULVA software, Wildi and Orloci 1990), in which the Dipper density (pairs/kms) is considered the dependent variable and the torrent characteristics the independent ones, we worked out the importance of the torrent features as correlates with the Dipper density .

Results

Distribution

The Dipper is now scarce in Sicily, with small populations becoming increasingly isolated; the distribution map for the 1979-1990 decade, together with some historical records, is shown in Fig. 1.

Breeding is certain (C) only in 9 UTM squares, corresponding to 3% of the whole grid representing Sicily in the Atlas Faunae Siciliae-Aves (Massa 1985); in 12 more squares breeding is possible (A). In 21 more squares the letter E (extinct) was used to indicate the areas where Dippers were recorded, as breeders, during the years 1950-79, and were checked but not found in 1979-90.This past distribution was worked out both from historical records and monitoring of the remnants of suitable habitats (dry and/or cemented river beds) located within the hydrografic basins in which this species was

encountered in the 1979-90 period. (•) indicates other historical encounters (1800-1950) both of breeding birds and wanderers.

The following is the summarized status relative to the main regions:

Conca d'Oro mountains (Palermo): the former presence of the bird in this area is presumed from reports from Doderlein (1869-1874) and from 3 stuffed individuals found along the upper Oreto valley in 1902 and 1907 (Whitaker and Orlando collections). Recent records (2 shooted individuals after 1960 and a third on 3 .12.1990) indicate its sporadic presence in winter, along the Oreto catchment, whose branches carry water only during the winter period.

Caronie and Peloritani mountains: until the past century, the Dipper was a common species (Giglioli, 1890); 27 individuals were stuffed between 1940 and 1960 (Priolo and Trischitta collections). Today this area is the only suitable environment for the species, which is present with probably the last viable population. The ongoing constructions in concrete could endanger the integrity of the last Sicilian stronghold for this species.

Madonie mountains: here the species was sedentary and common, in the opinion of Minà Palumbo (1857), Doderlein (1869-1874) and Giglioli (1890); 11 specimens were stuffed between 1932 and 1987 (Baglieri, Sorci, Orlando, Cannata collections). The Dipper is to be considered as virtually extinct here, for the drying up of most of the perennial torrents due to water collection and concrete construction carried out in the past 3 years, together with the prolonged drought. Occasionally, individuals may be encountered in the winter.

Sicani mountains: one encounter is reported by Krampitz (1958) along the Sosio river; later (1970) two more individuals were captured in the same basin. Three specimens (1902-32) from the Corleone area (Orlando and Whitaker collections) indicate the occurrence of breeding in a region included among the Sicani, Madonie and Palermo mountains. The research has confirmed the occurrence of breeding along the Sosio river; however, the recorded pairs were only 4 and the water level of the remains (12 kms) of this unique environment is quite unstable due to an upstream lock.

Iblei mountains: the species, considered as sedentary yet scarce in the Modica district, could still be found in suitable areas along the Anapo river and its tributaries . Its presence was reported in 1958 (2

Table 1 - Mean ± standard deviation features of five sicilian streams, where the Dipper (*C. cinclus*) population has been studied. Systematic Units refer to the number of macroinvertebrate taxa according to the EBI procedure; na=not available. All the characteristics, except downflow, pH and O_2, were used as indepedent variables to regress Dipper density in the same torrents.

	Scavioli	S. Fratello	S. Barbaro	Sosio	Rosmarino
Downflow	continuous	continuous	continuous	continuous	continuous
Turbulence (cm/sec)	4.5	4.5	3.5	3.5	3.0
Width of wet river bed (m)	4.5±1.1 (2.5-6.5; n12)	8.6±0.9 (7-10; n8)	3.2 (n3)	5.2±1.3 (4-7; n6)	10.4±2.7 (7-15; n10)
Width of dry river bed (m)	17.7±8.8 (12-40; n10)	19.6±3.4 (14-25; n8)	13.7 (n3)	15±5.3 (8-22; n8)	70.5±21.5 (45-100; n10)
Course depth (cm)	24.6±9.8 (10-50; n24)	80.6±43.1 (20-160; n16)	30.8±21.5 (5-50; n6)	59.2±33.1 (20-150; n12)	20±8.2 (10-30; n10)
Pool depth (cm)	61.7±17.4 (20-100; n24)	112±47.8 (40-200; n16)	73.3±23.4 (50-100; n6)	150±77.3 (70-300; n10)	43.3±15.3 (30-60; n10)
Gradient (m/km)	12.5%	8.5%	4.7%	3%	5%
Dominant substratum (diameter of stone)	mass of stones (>265 mm)	mass of stones (>265 mm)	gravel. pebbles (2-265 mm)	gravel. pebbles (2-265 mm)	gravel. pebbles (2-265 mm)
Water temperature C°	17.9±4.28 (5-27; n41)	17.3±1.3 (15-19; n10)	23.7±3.29 (20-29; n14)	19.6±1.5 (18-21.5; n9)	24.7±4.5 (19-29; n10)
pH	8.34±0.15 (7.85-8.48; n40)	8.36±0.07 (8.27-8.44; n20)	na	na	8.52±1.5 (6.3-11; n10)
% saturation of water O_2	105.9±8.1 (88.8-114.7; n36)	121.1±6.8 (114.3-132.2; n9)	96.4±6.0 (88.5-98.8; n8)	na	108.9±0.9 (107-109.9; n10)
Systematic Units	12.5	11	8	14.5	6.5

specimens in the Trischitta collection), and later between 1979 and 1983, by Priolo (1985) along the Anapo and Cassibile rivers. However, recent research (1990-92) has failed to confirm its presence in stretches of the same rivers. In all cases, the individuals recorded ten years ago belong to another relict small population not yet localized.

Habitat characteristics

The results of the habitat surveys on five rivers are presented in Table 1, whereas the results of the Dipper census are reported in Table 2. In the natural reaches of these torrents the average density is 0.63 pairs/km (± 0.29; 0.1-1; n=7); whereas in the canalized reaches, the species was always absent (0 pairs over 8 kms), with the observed disappearance of some breeding pairs due to the concrete construction of banks carried out from 1988 to 1990 on the Scavioli and S. Pietro torrents. Table 3 shows the results of the multiple regression test: the multiple squared correlation coefficient R is equal to 1 (F test for analysis of variance on $R = 16.96 > F_{9,5} = 13,8$; $P<0.005$). R measures the fit of the independent variables to the dependent one; the high value obtained, means that the variation in density can be fully explained by the simultaneous variation of the 9 variables characterizing the torrents. The variables which highly correlate (> 0.90) with the Dipper density have proven to be the substratum granulometry, turbulence and temperature; the last correlation being negative (i.e. the warmer the water the lower the Dipper density). The remaining variables, also show quite a high correlation (from 0.51 to 0.68); among these the course depth is liable to correlate positively with Dipper abundance only over a limited range (i.e. 0-10 m.; Ormerod in litt.). Only two variables, the pool depth and the width of wet river bed, does not seem to affect the Dipper density.

The better habitats are thus the larger branches of the mountain torrents which are highly hydrodynamic, with low temperature waters and the substratum made of big stones and large pebbles, such as the San Fratello or the Scavioli streams. The final reaches of these torrents with a slighter slope, wider bed, lower hydrodynamism and warmer waters, as well as the

Table 2 - The Dipper (*C.cinclus*) relative breeding density in some streams in Sicily. The linear home range is from 1000 to 2500 m. for a pair; in Wales it ranges from 300 to 2000 meters.The minimun length of a stream in which a breeding population exists is 10 km (Sosio, Mid-Western Sicily). (*) This high frequency results from excursions during the post-breeding season. n = n of excursions per stream in April-July and October-November 1988-90. One pair of Dippers disappared from the Scavioli stream due to damming work from 1988 to 1989. Linear densities from Scavioli 1989, S.Fratello, Sosio, S.Barbaro and Rosmarino were used as dependent variable to compute multiple regression analysis with the torrents characteristics as indipendents (Table 1).

	Stretch censussed (km)	Linear Density (pair/km)	Frequency (n 'contacts /t excursion)
Natural Stretches			
Scavioli 1988	9	0.78	0.044±0.02 (0.02-0.07; n9)
Scavioli 1989	8	0.75	0.038±0.02 (0.02-0.07; n5)
S.Fratello	4	1	0.082±0.05 (0.01-0.16; n6)
Sosio	10	0.4	0.031±0.03 (0-0.5; n5)
S.Pietro	1.5	0.71	0.01 (n3)
Milè	1.5	0.67	0.19 (*) (n2)
S.Barbaro	1.5	0.1	0.01±0.01 (0-0.2; n4)
Canalized Stretches			
Scavioli 1989	1	0	0 (n1)
S.Pietro and Milè	3	0	0 (n3)
Rosmarino	4	0	0 (n3)

Table 3 - Multiple regression analysis of Dipper density (Y = dependent variable) over 9 stream characteristics (X_1-X_9= indipendent variables). B' coefficients are the standard partial regression coefficients and give the rate of change in standard deviation unit of Y per one standard deviation unit of Xi (all other X variables kept constant). B are the conventional partial regression coefficients necessary to compute the regression equation; each B yields the rate of change of Dipper density as a function of a given X variable with the other kept constant at their means. Rs are the univariate correlations among the density and each indipendent variable. The intercept of the regression equation = 1.391.

Independent Variables	B'	B	R
Width of wet river bed (m)	-0.421	-0.059	0.004
Width of dry river bed (m)	0.111	0.002	-0.514
Course depth	0.230	0.376	0.664
Pool depth	0.187	0.185	0.382
Gradient	-1.050	-0.117	0.681
Substratum	2.638	0.015	0.914
Temperature	-0.182	-0.23	-0.961
Turbulence	-1.063	-0.672	0.944
Systematic Units	0.001	0.000	0.606

Table 4 - Results of the Extended Biotic Index procedure to assess water quality by macroinvertebrate sampling in some Sicilian stream. Number of Systematic Units (S.U.) per each taxonomic group used in the E.B.I. method arranged accorging the quality class at each station. The Dipper was absent (abs) from stretches of lower water quality (classes III-IV) whereas breeding (br) occured in higher water quality stretches.

	Scavioli1	S.Fratello1	Sosio1	Sosio2	Scavioli2	Rosmarino2	Rosmarino1	S.Fratello2
Trichoptera	7	0	1	2	2	2	1	1
Plecoptera	1	1	1	1	0	0	0	0
Ephemeroptera	2	4	2	3	4	3	4	2
Diptera	2	1	1	2	2	0	1	2
Eteroptera	1	2	0	1	1	0	0	3
Triclades	1	0	0	0	0	0	0	0
Oligochetae	1	0	0	0	0	0	0	0
Cleoptera	0	3	4	4	1	1	1	1
Odonata	0	1	3	2	0	0	0	0
Urudinea	0	0	1	0	0	0	0	0
Crustacea	0	0	0	1	0	0	0	0
Total S.U.	15	12	13	16	10	6	7	9
E.B.I. value	8	8	8	9	6	6	7	5
Quality class	II	II	II	II	III	III	IV	IV
Dipper	br	br	br	br	br	abs	abs	abs

tributary streams of the mountain torrents with shallow waters, narrow bed and absent flow during the summer months, can be then considered as secondary habitats. However, these streams play a crucial role in the spreading of the young birds and during the altitude migrations of the autumn-winter period, by allowing dispersal inside and among the basins (Price and Bock 1983). The density in these streams (e.g. San Barbaro) is very low and individuals are especially found during the post-reproductive period. In Wales, the abundance of nest-building pairs (Ormerod et al. 1986, Ormerod and Tyler 1987) is closely linked to slope and water hardness, as well as to the abundance of Plecopteran, Trichopteran and Ephemeropteran larvae, the main feeding source for the adults and youngsters. It is worth remarking that the same macroinvertebrate taxa represent key-groups for high quality water determination, according to the EBI methods.

Damiani (1988), by comparing EBI stations respectively located in a natural and a canalized bed of the Aterno river (Abruzzo - Central Italy), has found that the natural stream, with its 22 Systematic Units (n of taxa arranged according the EBI procedure), falls within quality class I, whereas the canalized reach, with only 4 Systematic Units, belongs to class IV and the Trichoptera, Ephemeroptera (except *Ecdyonurus* spp.) and Plecoptera are absent. It can then be hypothesised that the species should be present along streams with a higher EBI value. This is in agreement with the results gained from some EBI sampling along 5 of the 7 considered streams.

The species, in fact, breeds along the reaches with water of class II quality (8-9 EBI value) and is absent or occasionally present where the class becomes III-IV (5-6 EBI value) (Table 4). Abundance and quality of food is therefore important; the number of Systematic Units proved, in fact, to be positively correlated by multiple regression analysis, with Dipper density. Finally, it is worth remarking the higher taxonomic richness and relative abundance of Plecoptera, Trichoptera and Coleoptera found in the stretches where the Dipper breeds (Table 5). As cited by Ormerod et al. (1986) and Ormerod and Tyler (1987), all the chemical and physical parameters affecting the abundance and composition of the benthic fauna are also likely to influence the population density.

Table 5 - Mean number of S.U. (left) and numerical percentage (right) found in stretches where the Dipper is breeding or absent.

	Dipper breeding Mean S.U.	Dipper absent Mean S.U.	Dipper breeding % N	Dipper absent % N
Trichoptera	2.4	1.33	11.09	4.55
Plecoptera	0.8	0	3.12	0.00
Ephemeroptera	3	3	38.99	81.17
Diptera	1.6	1	16.64	7.14
Eteroptera	1	1	1.73	4.22
Triclades	0.2	0	0.35	0.00
Oligochetae	0.2	0	4.33	0.00
Coleoptera	2.4	1	17.68	2.92
Odonata	1.2	0	1.39	0.00
Irudinea	0.2	0	0.35	0.00
Crustacea	0.2	0	4.33	0.00
Mean S.U.	13.2	7.33		
Mean E.B.I. value	7.8	6		

Discussion

The location of Sicily on the edge of the European living range for the Dipper, makes the island, with its hot and dry Mediterranean climate, few and small rivers and torrents, an extreme habitat for the species. The Sicilian average density of 6.3 pairs/10 km matches the mean values reported by Roche (1988) for France (1.5-10.7 pairs/10 km) or by Ormerod et al. (1985) for Wales (2-8 pairs/10 km). The first limiting factor, as already recorded in Morocco (Tyler and Ormerod 1991), for the species distribution in Sicily is the presence and extension of a network of permanent streams. All the remaining factors (both anthropogenic and metereological), which alter the downflow and water quality within the island's suitable areas, were responsible for its decrease since the 1950. Ormerod and Tyler (1993) showed, how other pollutants than acidity, such as organic enrichment, can also affect Dippers by reducing food abundance. Since the montane streams and stretches house the nucleus of the reproductive population, every alteration of these will directly affect density. On the other hand, any alteration of the secondary habitats will cause the progressive isolation of the populations, as shown in the distribution map.

Adaptations to extreme Mediterranean conditions could be interesting to investigate. The Sosio Dippers, for example, suffered in 1991 a prolonged (at least July-October) water shortage from the upstream lock, that reduced the river to a sequence of pools and small basins without a continuous downflow; but this small nucleus (4 pairs so far recorded, that should be below the minimum viable population) was still breeding there in 1992.

Until the first few decades of the 20th century, the Dipper must have had a continuous distribution along the North-Western Ridge which includes the Peloritani, Caronie, Madonie and Palermo province mountains. The Eastern Sicani populations were probably connected to this area through the upper Belice basin, whereas the Southern Iblei populations were probably already isolated at that time. By adding the 21 squares marked with E and the other 21 in which the species results as a certain (C) or possible (A) breeder we should obtain an idea about the Dipper coverage in the 50s and 60s (14.1%). Therefore, the suitable area for the species has undergone a 57% decrease (in number of squares) in the last 30-40 years and it seems doomed to diminish even further, on the basis of the census carried out in 1991-92 in the Madonie and Ibleian mountains. Anyway, some records outside the breeding season, within the Conca D'oro and Madonie catchments (such as the bird shooted in December 1990 along the Oreto river or a second shooted in August-February 1991 along the Northern Imera river) can evidence either a certain

dispersion from the known breeding areas or the presence of small nuclei not yet localized.

The decrease of the distribution area and the isolation of the populations seems to follow the progressive drying undergone by the Sicilian basins in response to the synergic effects of anthropogenic and metereological factors. This process can be seen in the framework of a more general "anthropogenic desertification" in progress in Sicily and in the Mediterranean range of Dippers. Water resource development, catchment perturbation and water pollution is widespread in Southern Italy and generally in the Mediterranean region, and should be properly monitored also by using Dippers as indicators of water quality.

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Riassunto - Si riportano i dati di distribuzione e densità in Sicilia del Merlo acquaiolo (*Cinclus cinclus*), desunti da ricerche museografiche, bibliografiche e sul campo. La specie mostra una distribuzione molto localizzata in residue aree montane e la sua copertura è in diminuzione dagli ultimi 40 anni. La densità media in 7 torrenti presi come campione è di 6.3 coppie/10km, ed è comparabile a quella di altre aree europee, ma la specie è sulla soglia dell'estinzione a causa delle trasformazioni del suo habitat determinate dall'intervento umano e da fattori meteorologici. La presenza del Merlo acquaiolo è infatti fortemente legata a corsi d'acqua a deflusso ininterrotto, mentre la sua densità è correlata alle caratteristiche morfologiche dei torrenti (pendenza, substrato roccioso, altezza e temperatura dell'acqua, ecc.). La specie inoltre sembra nidificare esclusivamente lungo torrenti o tratti di questi dove è stata determinata, per mezzo del metodo E.B.I, un'alta qualità delle acque.

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