WINTER MOVEMENTS OF THE ALPINE CHOUGH: IMPLICATIONS FOR MANAGEMENT IN THE ALPS.

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Abstract - The home ranges and movements of marked Alpine choughs (*Pyrrhocorax graculus*) were investigated in Aosta Valley, western Italian Alps, in two study sessions: winter-spring 1996-1997 and winter-spring 1997-1998. Overall 28 birds were marked, six of these were also equipped with a small radio tag. Home range sizes of 17 birds were estimated with the minimum convex polygon method (MCP), harmonic mean analysis (HC) and Kernel analysis. Alpine choughs resulted to be highly gregarious: home ranges of marked birds in fact overlapped throughout winter and spring. Feeding areas location and home range sizes varied dramatically from October to May in both study sessions. Climatic factors, food availability and food quality probably influenced the spatial distribution of this species. Before the snowfalls, birds remained above the tree line, frequently using food provided by tourists at refuges and picnic areas. After the first snowfall in November most feeding took place in shrubbery at 1500 m. When the amount of snow cover became too deep the Alpine choughs came down to the valley bottoms and its surroundings (600-1000 m) to forage in apple-orchards by day and flew back up into the mountains to roost. In March and April these birds frequented villages at valley tops (visiting picnic areas or foraging in snow-free patches). In late spring, they went back to the higher grounds on the valley tops. The importance of tourist development and of traditional agricultural practices for Alpine chough winter survival is discussed.

Key-words: Alpine chough, *Pyrrhocorax graculus*, radio-tracking, winter movements, agricultural practices.

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1. Introduction

Alpine chough (*Pyrrhocorax graculus*) occurs in middle latitudes of west Palearctic, in generally cold climates (Cramp & Perrins, 1994). It is a bird of high mountainous areas: in summer it inhabits high pastures and cliffs, nesting in steep rock-faces (in caves or fissures), in winter it descends to valleys below the tree line searching for snow-free patches (Goodwin, 1986). Population sizes and trends in Europe are generally poorly known: almost 50% of the breeding population and 73% of the population size trend estimates are based on non-quantitative data or have no estimates (Tucker & Heath, 1994). Concerning Italy, in the Alps the populations seem stable with no major fluctuations (Frugis, 1993); conversely, the Alpine chough is declining in the Apennines, as a consequence of breeding and wintering habitat losses (De Sanctis, 1996).

Alpine choughs are social birds: they are highly gregarious throughout year, commonly occurring in small or large flocks, but sometimes in pair or family parties (especially during the breeding season) (Cramp & Perrins, 1994).

In summer, in the Alps this bird generally forages in single species or mixed species (*i.e.* with the Red-billed chough *Pyrrhocorax pyrrhocorax*) assemblages on a variety of invertebrate prey; on pastures surface it actively chases and collects grasshoppers, beetles, caterpillars and fly larvae (Rolando & Laiolo, 1997). In autumn, winter and early spring, Alpine choughs mainly rely on fruits: berries, hips, cultivated apples, grapes and pears (Glutz von Blotzheim, 1962; Dendaletche & Saint-Lebe, 1987; Laiolo & Rolando, *in prep.*). In the western Italian Alps assemblages with the choughs are scarce in this time of the year, and a complete niche partitioning (diet overlap close to zero) has been observed (Laiolo & Rolando, *in prep.*)

Alpine chough is also known to use food sources provided by tourist activities (Holyoak, 1972; Delestrade, 1989). Especially in winter, in fact, this Corvid favours immediate neighbourhood of huts, ski stations, hotels and other tourist facilities. Since a supply of human foodscraps is available all over the year in many valleys tops, some Alpine chough populations may remain in the higher ground for the whole year (Delestrade, 1994; Büchel, 1983). Struch & Fankhauser (1994) reported that 200 years ago Alpine choughs seemed to roam about more than nowadays, as they formerly depended more on natural resources. In summer the association with human dwellings seems to be less marked: Rolando & Patterson (1993) found out that breeding pairs show a certain aversion to human presence and human settlements, preferring to forage on natural pastures.

Despite studies of radio-tagged Alpine choughs in summer (Rolando & Patterson, 1993), little information has been collected on this species movement in winter and spring. The aims of this study were two-fold:

i.) to provide a general description of winter movements and of ranging behaviour for marked Alpine choughs in Aosta Valley (Cogne Valley, Gran Paradiso National Park);

ii.) to assess the importance of man-related activities for this species in harsh winter conditions.

2. Study area and methods

The study was carried out in Cogne Valley and its surroundings (Dora Baltea valley bottom, Aosta Valley, Italy, Fig. 1), from October 1996 to May 1997, and from November 1997 to March 1998. The area consists of alpine meadows and mountain cliffs (above 2000 m a.s.l.), of coniferous forests (1000-2000 m) and of broadleaf or mixed woodland, cultivated areas (mainly orchards) and villages (600-1000 m). Part of the study area is a protected zone (Gran Paradiso National Park) and receives tourists both in winter and in summer.

In Valnontey (Gran Paradiso National Park), at 2600 m a.s.l., Alpine choughs were baited with bread and sultana raisins (Büchel, 1983) and trapped using monofilament nylon nooses. Overall 28 Alpine choughs were caught, 25 in 1996 and 3 in 1997.

At capture, each Alpine chough was measured for several morphological variables. The following measures were taken: weight, wing length, tail length, tarsus length, bill length at nostril. All birds were individually marked by bleaching a few feathers and ringed with plastic colour rings. Six birds (4 in 1996 and 2 in 1997) were also equipped with radio transmitters (2-4 g, *i.e.* less than 2% of the birds body weight) tied and glued to the base of the 2 central tail feathers (Kenward, 1987). The tagged birds were located by triangulation or by sight, while marked birds without tags were located only by sight. The positions were

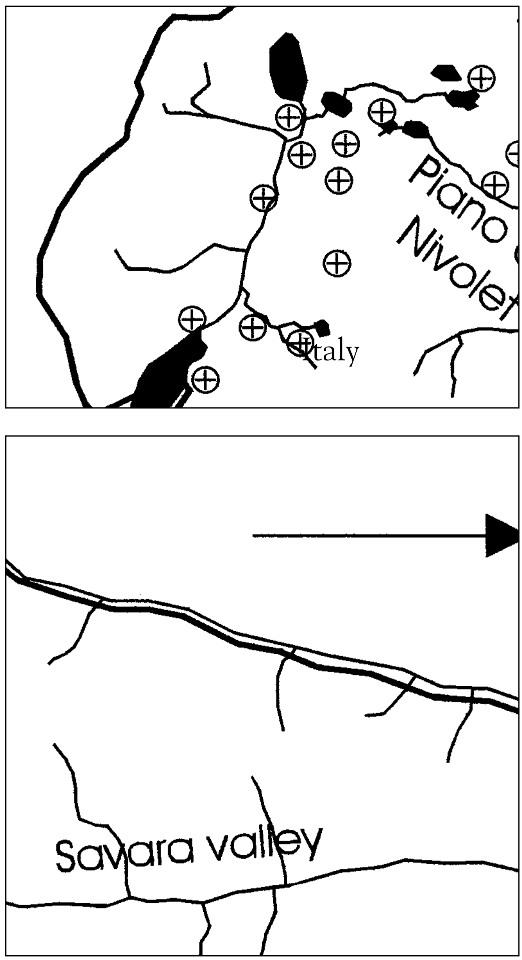

Fig. 1 - Location of the study area.

recorded at 15 minutes intervals on 1:25,000 scale maps of the study site. A 500 x 500 m grid was used.
The observation period was divided into different stages, in relation to snow-conditions:

- 1st period = before the snowfalls (27/10/96-8/11/96 in the first winter and 1/11/97-6/11/97 in the second winter);
- 2nd period = first snowfall and low snow cover (9/11/96-27/11/96 and 26/11/97-20/12/97);
- 3rd period = heavy snowfalls and deep snow

Tab. 1 - Measurements of the 28 Alpine Choughs caught during the two years of study.

Alpine cough number	Weight (g)	Wing lenght (cm)	Tail lenght (cm)	Tarsus lenght (mm)	Bill lenght (mm)
AC1*	284	28.80	18.00	46.60	23.40
AC2*	226	28.00	17.20	43.70	22.06
AC3	252	29.40	18.40	46.80	22.40
AC4	246	28.00	18.00	46.04	20.40
AC5	225	27.90	17.90	44.20	22.20
AC6	235	28.50	17.60	46.90	23.50
AC7	332	29.40	19.20	45.80	25.11
AC8	187	28.30	18.01	45.18	22.68
AC9*	259	28.10	18.80	45.96	23.19
AC10*	221	27.20	17.40	43.36	20.64
AC11	279	28.10	17.80	46.15	23.10
AC12	187	28.60	17.80	45.13	23.86
AC13	225	26.60	17.00	46.00	21.47
AC14	256	27.10	17.90	46.70	22.70
AC15	221	25.80	16.20	41.96	20.65
AC16	250	28.20	18.00	47.40	21.90
AC17	233	27.20	17.50	44.70	21.00
AC18	205	25.90	17.70	41.60	23.05
AC19	249	28.30	18.50	47.50	23.10
AC20	200	26.00	16.30	44.40	19.70
AC21	252	27.60	18.84	49.40	23.80
AC22	235	28.60	18.10	46.40	21.60
AC23	251	28.70	18.60	46.00	24.40
AC24	250	28.90	18.75	44.20	22.10
AC25	203	24.50	15.90	43.60	20.10
AC26*	230	26.30	17.10	47.50	21.20
AC27*	240	28.40	17.50	47.20	22.30
AC28	195	26.20	17.70	43.00	21.80

* = radio-tagged birds.

cover (28/11/96-14/2/97 and 3/1/98-2/3/98);
- 4th period = snow melting (15/2/97-30/4/97 and 5/3/98-22/3/98);
- 5th period = snow line above 2000-2500 m (May 1997 only).

The Range V software system (Kenward & Hodder 1996, Institute of Terrestrial Ecology, Wareham, U.K.) was used to analyse data. Range sizes were calculated using the minimum convex polygon method, including 100% and 95% of the fixes (MCP 100% and MCP 95% respectively), the Kernel analysis (KER 95%) and the harmonic mean analysis (HM 95%). We chose the analysis option to include the roost in the home ranges. Differences between home range sizes were tested by non-parametric techniques.

3. Results

Measurements of the 28 Alpine choughs are presented in Tab. 1. Mean weight, mean wing

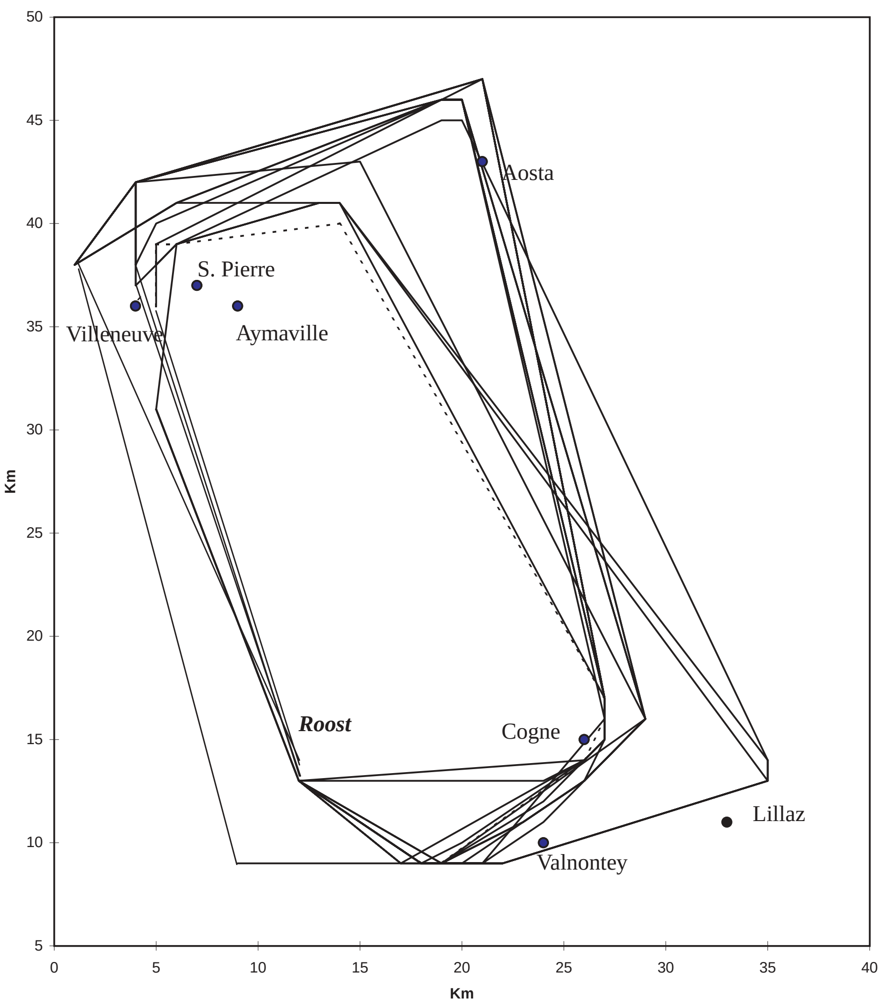

Fig. 2 - Ranges of 17 marked Alpine Choughs. Contours obtained by MCP 95%. Heavy lines: winter and spring 1996-1997; dotted lines: winter and spring 1997-1998; Black dots: cities and villages.

Tab. 2 - Number of fixes and home range sizes for the marked Alpine Choughs.
Home range sizes were estimated by minimum convex polygons (MCP 100% and MCP 95%), by harmonic mean analysis (HM 95%) and by Kernel analysis (KER 95%).

Alpine Chough number	"Number of fixes"	"MCP 100%" (ha)	"MCP 95%" (ha)	"HC 95%" (ha)	"KER" 95%(ha)
AC1*	1,416	21,563	17,250	10,843	8,993
AC2*	961	21,275	16,138	15,802	9,805
AC3	620	16,038	15,850	9,379	8,878
AC6	248	13,225	12,738	6,287	7,738
AC7	243	20,087	16,838	9,321	10,253
AC8	424	19,538	16,025	9,402	9,571
AC9*	1,221	23,213	19,063	13,548	7,601
AC10*	1,211	17,425	16,288	14,598	7,611
AC11	255	15,188	14,988	7,411	9,256
AC12	317	19,325	16,163	12,519	10,432
AC14	733	16,425	16,000	11,925	8,948
AC15	386	19,400	17,888	6,958	8,347
AC16	222	15,475	15,300	11,119	6,379
AC18	391	15,250	15,087	8,335	7,889
AC22	591	17,475	14,663	7,726	7,785
AC26*	839	11,600	10,887	10,074	5,333
AC27*	790	11,600	10,887	15,972	6,023

* = radio-tagged birds.

Tab. 3 - Number of fixes and home range sizes of Alpine Chough AC1 throughout the study period.
Home range sizes were estimated by minimum convex polygons (MCP 100% and MCP 95%), by harmonic mean analysis (HM 95%) and by Kernel analysis (KER 95%).

Period	Number of fixes	MCP 100% (ha)	MCP 95% (ha)	HM 95% (ha)	KER 95% (ha)
October - early November	100	1,388	238	640	37
mid - late November	131	4,663	2,738	3,532	2,709
December - mid February	917	15,788	8,575	23,535	4,093
mid February - April	363	3,400	788	1,827	486
May	7	500	500	232	1,548

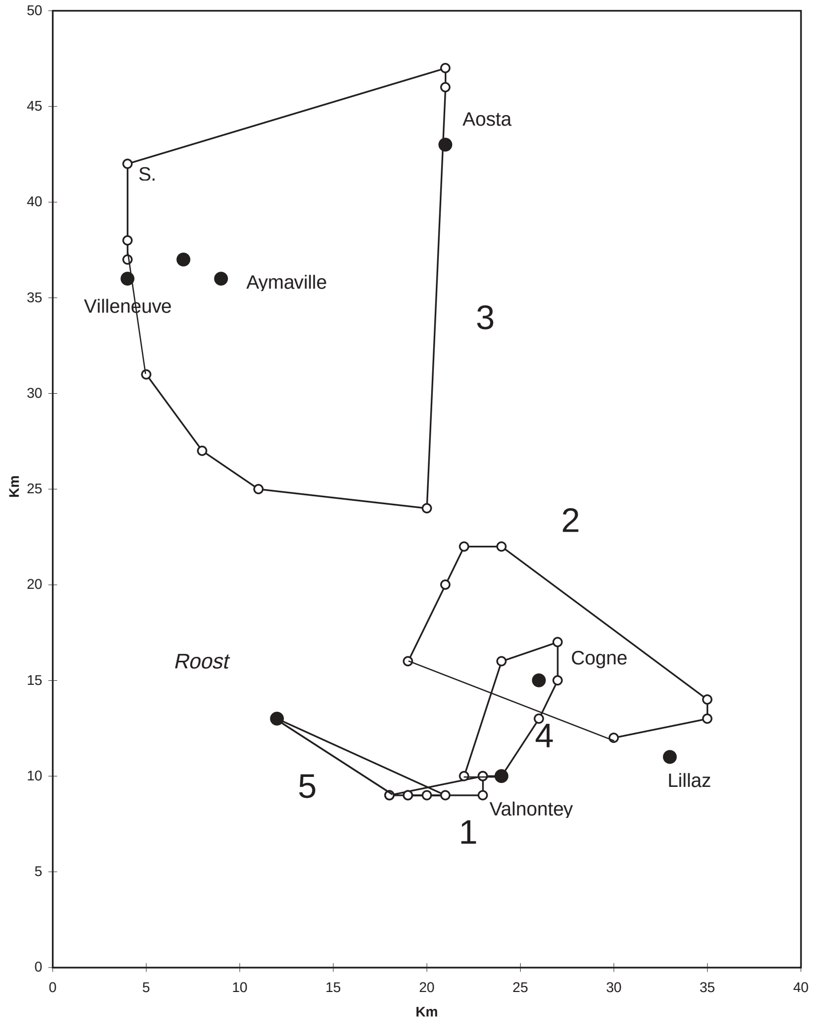

Fig. 3 - Ranges of Alpine Chough AC1 throughout the study period. 1 = before the snowfalls; 2 = after a first snowfall; 3 = after heavy snowfalls; 4 = early spring; 5 = May. Contours obtained by MCP 95%; Black dots: cities and villages.

length, mean tail length, mean tarsus length and mean bill length resulted to be, respectively: 236.7 g (±31.2 SD), 27.7 cm (±1.2 SD), 17.8 cm (±0.8 SD), 45.5 mm ± 1.8 SD and 22.3 mm (±1.3 SD). In this species adults, yearlings and immature can be distinguished by their leg and plumage colours: black legs and brown feathers and white/yellow bill with a black tip in juveniles, black legs and brown feathers yearlings, red legs and black feathers in adults (Delestrade, *in press*). All the birds we caught were adults.

We estimated the home range size of 17 out of 28 birds, *i.e.* for the birds with a data set large enough for statistical analyses.

The 15 marked Alpine choughs of 1996-1997 and the 2 birds of 1997-1998 had overlapping home ranges, using communal areas for roosting and for feeding (Fig. 2). The range size of all marked birds resulted to be very large (MCP 95% range: 108.87-190.63 km^2; HM 95% range: 62.87-159.72 km^2; KER 95 %

range: 53.33-104.32 km^2).
Significant differences were obtained among the home range sizes estimated with the different methods (Friedman test, chi-square = 23.65, d.f. = 2, N= 17, P<0.001, Tab. 2). Particularly, Kernel and harmonic mean analyses revealed the presence of two main areas of activity, one located in the upper (southern) part of Cogne Valley, the other at the bottom of the valley and its surrounding areas. For each method we also compared the home range sizes of tagged and not tagged birds: significant differences resulted only in the case of HC95% (Mann-Whitney U test: U=6.0, N=17, P=0.0067).

The home range sizes and position varied dramatically throughout the study period (Fig. 3 and Tab. 3). Before the snowfalls, birds remained above the tree line (2500-3000 m), frequently using food provided by tourists at refuges and picnic areas inside Gran Paradiso National Park. After the first snowfalls birds abandoned the foraging grounds of the Park, but kept roosting by night inside of it.
In November, most feeding took place in shrubbery at 1500 m, up to 10 kilometres from the roost. In the third period the home range size increased greatly: Alpine choughs came down to the bottom of Cogne and Dora Baltea valleys (600-1000 m) to forage in apple-orchards and flew back up into the mountains to roost, undertaking daily movements over 20 kilometres and descending and climbing as much as 2000 m each day. These birds generally stayed in apple orchards from 8-9 a.m. to 13-14 p.m., feeding on the apples left on few trees and, after a partial snow melting, on the ground above the trees. Flocks over 1800 birds were recorded in apple orchards, resulting from the aggregation of birds from many different valleys. In March and April birds frequented Cogne village, at the border of the Gran Paradiso National Park, either visiting picnic areas to feed on human foodscraps or foraging in snow-free patches (where they ate earthworms). In May, when weather conditions improved, Alpine choughs went back to the higher grounds on the valley tops, but continued to eat food thrown to them by tourists.

4. Discussion

The home ranges of the marked Alpine choughs resulted to be similar and overlapping throughout the study period. This gregariousness might be due to food distribution, patchy in both space and time: with such a clumped and shifting food supply the best option might be to feed in groups (Delestrade, 1994). The Alpine chough proved to be remarkably flexible in its ranging behaviour, since feeding areas location and home range sizes varied dramatically from October to May. Climatic factors, food availability and food quality probably influenced the local and seasonal distribution of this species. Winter is notably a critical period on high mountain tops, since deep snow cover and low temperatures result in permanent food shortage conditions. This appeared to be particularly true in the third period of our study, and birds greatly enlarged their ranges. At this time of the year the amount of snow cover was such that remaining at the top of the valley, despite the permanent supply of tourists' foodscraps in Cogne village, was not a viable option. The birds probably had to use lower level feeding grounds (apple-orchards) to find sufficient (and better quality) food. The high plasticity resulted in ranging behaviour is associated with a great trophic flexibility: this species managed to exploit food provided by tourists as well as natural resources such as berries or fruits from cultivated orchards. Laiolo & Rolando (*in prep.*) observed the same pattern of variability in Alpine chough winter diet in another study site of Aosta Valley. We might therefore state that Alpine chough is an opportunistic bird, at least for feeding. It can exploit the resources that are available and more profitable in each period. This high plasticity is confirmed by the Alpine chough ability to find alternative foraging ground (apple orchard, human dwellings) when the amount of snow cover on natural resources is too deep.

But to what extent does Alpine chough depend on food sources directly provided by man? Despite no comparative study has been undertaken on the precise extent to which tourism newly created opportunities for food have been taken up, we might assert that resources furnished by tourist activities are not the basis of Alpine chough diet but only a complement: the Alpine chough population of Cogne exploited human foodscraps, but generally in association with natural food (berries in autumn-early winter, earthworms in spring).

Oppositely, some low-intensity agricultural habitat types such as perennial crops are of particular importance for the Alpine chough in winter. Permanent crops such as apple orchards can be considered traditional agricultural habitats, despite nowadays they run on a more intensive basis. The Dora Baltea valley bottom underwent dramatic changes over the last 20 years: semi-natural habitats and low intensity farming systems (pasture grassland, potatoes, cereal and other crops cultivations, shrubberies) have been increasingly neglected or even abandoned, largely owing to urbanisation, land abandonment and conversion to other agricultural systems (poplars plantations, afforestations) (Framarin, 1996; Bocca & Maffei, 1997). The most widespread habitat losses and degradation probably result from increasing urbanisation with the expansion of industrial and commercial areas. Disturbance is a side effect of this transformation and may alone cause desertion of the left suitable areas. Moreover, new habitats created by afforestation and large-scale abandonment of farmland habitat, which are replaced with forest (Dupont, 1996), made some areas no more exploitable by the Alpine chough.

When heavy snowfalls force birds to forage downhill, the only suitable refuges left are orchards, consisting of a scattered tree cover with an understorey of open grassland. Here the advantage is two-fold: Alpine choughs manage to find good quality food and disturbance is scarce.

When also this farming system disappears, wintering Alpine choughs might develop a closer association with humans, which guarantee a permanent food supply. Hence, ready acceptance of "artificial" food provided by man might be considered a consequence of the loss of prime habitats.

This hypothesis might explain the phenomenon that, notwithstanding this Corvid exploits sources created by tourism, no increase in population sizes is recorded, conversely to what was observed in other opportunistic species such as House Sparrow (*Passer domesticus*) (Summers-Smith, 1963), Black-headed Gull (*Larus ridibundus*) (Källander & Lebreton, 1997) or Herring Gull (*Larus argentatus*) (Harris, 1970). Likewise, Alpine chough did not increase the range of its distribution in the Alps (see Delestrade, 1991 for a review). Data available are not conclusive, but certainly the link between habitat changes, Alpine chough behavioural adaptability and anthropophily merits further study.

Population dynamics apart, association with man combined to habitat losses might potentially affect Alpine choughs ranging behaviour in winter: since a supply of human foodscraps is available all over the year in some valley tops, a few populations may become remarkably sedentary, greatly limiting their altitudinal movements (*unpublished data*).

This distortion in Alpine choughs behaviour should be prevented, and management programmes for the maintenance of existing low-intensity farming systems or seminatural habitats at valley bottoms might allow birds to access to more of their traditional (and natural) food (*e.g.* any kind of fruits), thus avoiding "commensalism" with humans. It is worth noting that the same policy of maintaining low-intensity agricultural areas, as well as the conservation of pastoral practices (including the transhumance livestock systems), could also favour the rarer and more vulnerable Red-billed chough (Bignal, 1994; Bignal & Curtis, 1988; Rolando & Laiolo, 1996).

In Europe conservation efforts have mainly concentrated on natural habitats and few protected areas for 'agricultural species' have been designated. This is partly due to the mistaken, but widespread, view that agricultural habitats are of low conservation importance (Tucker, 1996), but to avoid detrimental changes in the Alpine chough behaviour measures should be introduced to maintain the presence of these suitable habitats.

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