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Twenty-seventh year of the Alpine marmot introduction in the agricultural landscape of the Central Massif (France)

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A small population of Alpine marmots was introduced near the top of the Mézenc Massif (France) in 1980 and reinforced 7 times until 1991. An annual monitoring was performed since 1988. It took 12 years to the population size to reach the number of marmots released. Afterwards the population doubled every 7 years, despite several population crashes (in 1997 and 2001). The currently censused 492 marmots were distributed into 86 sites on an area of about 200 km^2 in 2007. A Multiple Correspondence Analysis of demographic and environmental parameters of each site showed that marmots preferred, these last years, anthropogenic sites (meadows, dry stone walls, elevation under 1200 m) where reproduction rate was highest. Thus, marmots are now competing with farmers for space. In the same time, tourism increased strongly, especially tourism related to marmot spotting. The interactions between the presence of marmots in this agricultural environment and human activities are described, and their consequences are considered in the context of the sustainable development of the Mézenc Massif.

KEY WORDS: *Marmota marmota*, introduction, farming, tourism, sustainable development.

INTRODUCTION

Before the Second World War, the Alpine marmot, a rodent indigenous to the Alpine Massif, was threatened in France (creation of the first nature reserve to protect marmots, Lauzanier; Marié 1936). Marmots were present in the six French Alpine departments and classified as game. Since then numerous re-introductions in the pre-alpine Massifs and introductions in the Pyrenees (1948) and the Central Massif (Sancy Massif, 1959; Mézenc Massif, 1980; Cantal Massif, 1989) were carried out (Ramousse et al. 1992), most of them before the establishment of international recommendations on introductions (Council of Europe 1985, IUCN 1987). Marmots are now present in 18 French departments (Deloche & Magnani 2002) and classified as protected species in the re-introducing departments. But none of the re-introduction and introduction operations resulted in long-term monitoring, except the Mézenc one. It took place mainly in an agricultural area.

A preliminary analysis of the colonization process of the Mézenc marmots has already been presented (Ramousse et al. 2003) and data are available online and actualized every year (Le Berre et al. 2007). In this work, in the light of 27 years of monitoring data, the analysis of the colonization process of Mézenc marmots is updated and its impact on economic activity in an agricultural region is estimated.

MATERIAL AND METHODS

Study area

The Mézenc Massif, an extinct volcano on the Southeast edge of the Central Massif, rises to 1754 m, with a mean altitude about 1100 m a.s.l. The massif overlaps the plateau of the Haute-Loire department (Atlantic or Loire Basin) and the downslopes of the Ardèche department (Mediterranean or Rhône Basin). Summers are short and cool, winters long and snowy, resulting in a short growing season, even more unpredictable as frosts may be early and/or late, making cultivation difficult. Also, high pastoralism pressure and high human density, entirely deforested the massif until the end of the 19th century. Since then, reforestation of the summits was carried out to control the rising of the rivers of the Mediterranean Basin. The open environment consists mainly of moor-lawn mosaics, improved hay meadows, rock accumulation and screes.

Introduction history

If marmot presence during prehistorical time is confirmed in the valleys (around 700 m) of the Central Massif (Pomel 1853), no reference to this species is known during historical times. Thus, the marmot release in 1980 in a scree of the Mézenc Massif was the premise of an introduction. This operation was led by the departmental federation of hunters of the Ardèche department, with the help of rangers of the National Office of Hunting and Wildlife, after obtaining regulatory approvals (Chief administrator of the department, mayors, owners of the land). The objectives of this operation were the biological enrichment of the ecosystem, the diversification of food resource for large raptors, and the tourism development related to the attractiveness of the marmot. The first

release (11 individuals) was followed by seven reinforcements (median per operation of 12 animals). Thus, 108 unmarked marmots have been introduced in the Mézenc Massif.

Monitoring

Wildlife rangers have conducted the monitoring of the population, discontinuous until 1988, and annually afterwards. A network of local informants reports all new settlements. Each settlement is observed 5 times through spring to autumn. Two categories of individuals are distinguished, young of the year and others. The number of animals of each category chosen for each site is the largest number of animals observed simultaneously during the counting season. Family groups, at least two individuals seen at the same time on the same burrow system, are distinguished. On the same site, it is possible to have until three contiguous family groups.

So, for each site, we have both ecological (location, altitude, sun exposure, relief, vegetation, rock presence, water presence) and demographic data (number of family groups, number of young, number of adults, number of litters and an index of site fidelity).

Data analysis

A non-parametric multifactor analysis (Multiple Correspondence Analysis, THIOULOUSE et al. 1997) was performed on a contingency table of 13 variables, ranked into 38 modalities, of 53 sites followed at least 6 years. Values of 5 demographic and 8 ecological variables were ranked as followed:

1. Mean number of marmots per year in each site: <4.24, >4.24-<8.05, >8.05;
2. Mean number of family groups per year in each site: <0.80, >0.80-1.46, >1.46;
3. Mean number of litterings per year in each site: <6, >6-12, >12;
4. Mean number of litters per year in each site: <0.50, >0.50;
5. Site fidelity: a family group disappears one or more years from a settlement site (discontinuous settlement), a family group is present each year on the same site (Continuous settlement);
6. Altitude in meters: <1200, >1200-1400, >1400;
7. Sun exposure: North-Northeast, East-Southeast, South-Southwest, West-Northwest;
8. Relief: shoulder and gentle slope, gentle slope, steep slope;
9. Vegetation: meadow, heathland, meadow-heathland;
10. Rock presence: no rocks, dry stone walls, screes;
11. Water: spring, brook, no water;
12. Date of first colonization of a site: 1980-1989, 1990-1999, >2000;
13. Anthropogenic pressure: null, pasture, and hay meadow.

RESULTS AND DISCUSSION

Dynamics of the introduction

The total number of marmots increased steadily from 36 in 1988 to 492 in 2007 (Fig. 1). The rate of population growth per year varied from – 0.16 to 0.57 (median = 0.12), which corresponds to a time of doubling the population of 5.92 years, despite some demographic accidents in 1990, 1993, 1997, 2001. During

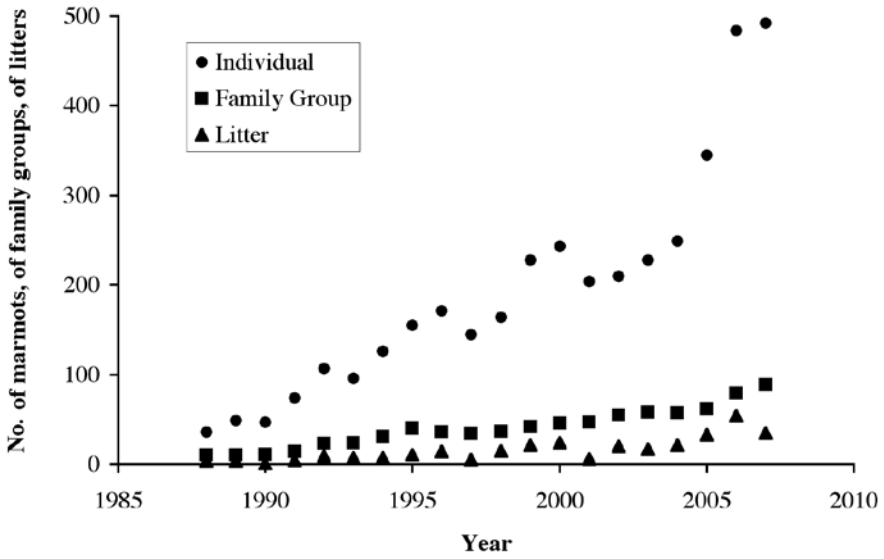

Fig. 1. — Dynamics of the number of marmots, between 1988 and 2007. Plain circle: number of marmots observed each year; plain square: number of family groups observed each year; plain triangle: number of litters observed each year.

those years, the decrease of the population was the result of a sharp reduction of reproduction (few litters and young of the year, and constant number of family groups, Fig. 1). Two observations showed that during the releases, marmot losses are significant. The number of marmots in the population needed 13 years to reach the number of released marmots. When 36 marmots were observed in 1988, only 49 marmots were counted at the end of 1989 in spite of the release of 32 marmots that year and, moreover, the population decreased in 1990.

Mézenc Mount culminates at 1754 m and the thalweg of the Mediterranean side lays around 800 m. Most of the marmots settled between 1300 and 1500 m, but since 2000 there is a significative trend to settle downslope, up to 1100 m (Chi square = 8.7, df = 2, $P < 0.02$, Fig. 2). The settlements at low altitudes (under 1350 m a.s.l.) are significantly more numerous on the slopes of the Mediterranean Basin than on the plateau of the Atlantic Basin (Chi square = 3.8, df = 1, $P < 0.05$).

Colonization distances correspond to straight-line distance between each marmot site and the reference point of the first release. Up to 1988, marmots stayed in a radius of 3 km around the releasing point. From 1989 to 2004, new settlements occurred between 5 and 10 km from the reference point. In 2007, the most remote points of colonization were situated at 17.5 km from the reference point. At the same time as some settlements became more distant from the reference point, other family groups clustered together in the pioneer areas.

The number of family groups settled in 2007 was 89. The number of marmots and the number of family groups settled in the Atlantic Basin were always lower than in the Mediterranean Basin (Wilcoxon test, T = 0, $P < 0.01$). Moreover, marmots colonized earlier the Mediterranean than the Atlantic basin (the

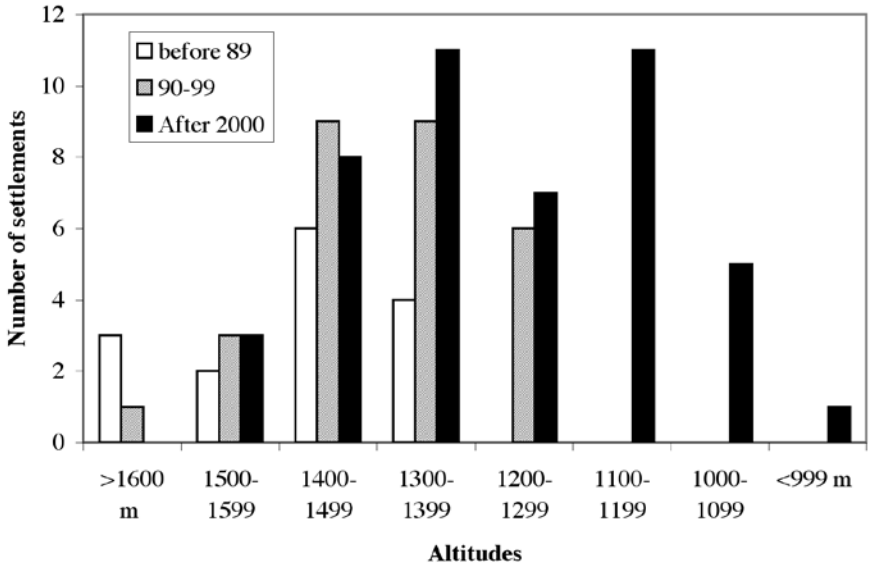

Fig. 2. — Altitudinal distribution in each decade in the Atlantic and Mediterranean Basins.

number of marmot settlements in the Mediterranean Basin were more numerous before 1993 than in the Atlantic Basin, Chi square = 4.38, df = 1, $P < 0.01$).

Now, marmots are present on 22 of the 31 communes of the Massif: 14 communes out of 16 in the Ardèche department, 8 out of 15 communes in the Haute-Loire department.

The Multiple Correspondence Analysis of 8 ecological and 5 demographical variables emphasizes two factors explaining 53% of the information of the contingency table (Fig. 3). The first factor (40.1% of information) opposes ten sites with the highest levels of reproduction to nine sites with the lowest reproduction level. High level of reproduction (high number of yearlings, of litters, of marmots, of family groups) was observed in anthropogenic sites (Hay meadow, dry stone walls) located at low elevation (under 1200 m a.s.l.). Although sites located in natural environment (heathlands near screes, high elevation) were not favourable for breeding, some of them were regularly reoccupied and could act as temporary shelter sites for dispersers.

The second factor (13.2% of the information) opposes eight early colonization sites located in mixed landscapes (meadow-heathlands) with a median number of marmots to four late colonization sites located in hay meadows near brook with few marmots. Marmots settled over time a network of burrows and shelters in ancient sites, which can house despite a poor environment, many family groups with litters. But these groups are smaller and have fewer yearlings than in anthropogenized meadows. In newer sites, the absence of such a shelter network makes it more difficult to maintain groups of marmots, especially in wet area near brooks. An increasing disturbance of family marmots by dogs digging the burrows these last years have also been observed particularly in the new sites.

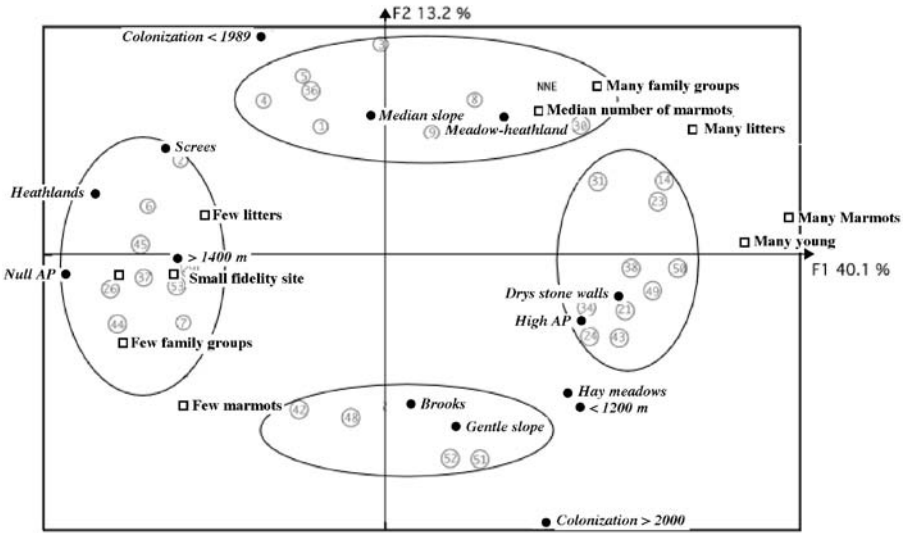

Fig. 3. — Factorial planes F1 and F2 of the Multiple Correspondence Analysis of ecological and demographical data of marmot settlements. Explanatory modalities (important absolute and relative contributions) are described for each factor (open square and Plain: demographical modalities; open circle and italic: ecological modalities). Characteristics sites (important absolute and relative contributions) are grouped by ellipses (number in circle).

This analysis including demographical variables confirms and specifies previous analysis RAMOUSSE et al. (2003). The colonization dynamics is different between the two river systems. Colonization occurred earlier, more important and at lower elevation in the Mediterranean than in the Atlantic Basin. This difference may be just the result of the greatest number of marmots released earlier in the Mediterranean Basin (69 individuals in MB, 29 individuals in AB).

More importantly, the process of colonization followed the same trend in the two basins, as well as in the Pyrenees (GIBOULET et al. 2002). Marmots settled first in areas with natural shelters at high elevations (screes and rock outcrops) and then in lower elevations in more open lands. But in the Mézenc Massif, contrary to the Pyrenees, at lower elevations there are mainly improved meadows instead of grasslands. Improved meadows are more attractive for marmots than grasslands. In these meadows, vegetation is more abundant and the presence of dry stonewalls and banks provide marmots with man-made shelters almost ready to use. This kind of anthropogenic landscapes is very attractive for alpine marmots as well as for bobac marmots (RUMIANTSEV & BIBIKOV 1996) in Russia. If the growth of the population of marmots is keeping up, we will have to face an invasive process.

Socio-economic context of the Massif

LE BRET et al. (2008) have compiled the data quoted in this paragraph.

Administrative context. The Mézenc Massif is bounded by volcanic lands with elevations above 1100 m, corresponding to the 70,928 ha of 31 communes. The population density averages 13.5 inhabitants/km² (vs 120 i/km² in France).

Various public policies contribute to preserve the natural heritage. For example, the inventory of ecologically interesting natural areas and a Regional Natural Park involving local authorities try to maintain and manage the natural heritage in the context of a sustainable development. This Park could be the framework for coordination among the development actors of the Massif.

Agricultural activity. It is the first pole of economic development. The Mézenc is classified as mountain area, receiving a state compensation for its natural handicap. The usable agricultural area (UAA, area devoted to agricultural production) is mainly composed of hay meadows (40%) and pastures. Extensive cattle breeding (0.78 livestock unit) is the main activity. This system of farming does not use excessive fertilization or the overturning the soil.

However, a significant population decline led to ageing farmers and a sharp decrease in the number of farms, but without a decrease of the UAA. The expansion of farms has led to a decline in the maintenance of the grass areas, especially on the slopes. Currently, two programs, funded by the Departments, support the retention and expansion of grassland, one by the regrouping or burying of scattered rocks and the other one by grinding of brooms.

Tourism. Tourism is the second pole of economic development of the Massif. Tourism assets of the Massif are numerous: different scenic landscape monuments (volcanoes, phonolitic mounts, large panoramas), rich biodiversity (Arctic relics), a varied architectural heritage and an important snow cover allowing winter sports.

Hotels and holiday centers, mainly located in one village, provide 100,000 nights per year all the year long. They offer all kinds of recreational sports with instructors and guided walks to see wildlife, geologic or architectural and historical heritage. Many second homes (41% of habitat) also allow the stay of tourists. Natural sites are visited on day excursions (e.g. Gerbier de Jonc mount: 500,000 visitors per year). Hikers can enjoy a network of mountain lodges. These activities have resulted in an increase in the number of tourist operators, an increase of the population and its rejuvenation.

Marmots and the development of the Mézenc Massif

Marmots compete with farmers for hay meadows, the more profitable lands. Marmots cause inconveniences (farm equipment damage, injury of domestic animals) and losses of time and income by making farming difficult or impossible, especially for hay harvesting. For example, in 2006 three farmers complained of having lost, respectively, 4.8, 1.5 and 12% of their arable land because of marmots. But they also complained of an increase of tourist trampling in their meadows.

By their activity, farmers maintain openness of the landscapes favorable to marmot settlements but also attractive to tourists, but they feel they derive any benefit from the presence of marmots or of the tourists.

Economic impact of the marmots on tourism is hardly measurable. But marmot is an attractive and easy to see species, which led to the demand for tours. For example, 1600 tourists were charged for marmot tour in 2007. A dozen of Mountain Guides is working on the Massif, and offer various thematic walks. In the opinion of tour operators, marmot became the mascot of the local tourism and helps to publicize other activities. The problem is that only one village in the Massif benefited from the extensive development of tourism.

If tourism is the future of the Mézenc Massif, its development requires the maintenance of other activities and particularly of agriculture. It is now necessary to pool the costs and benefits caused by the marmots on the Massif. The search for acceptable and beneficial solutions for all is now at major public consultations.

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