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Alpine marmot populations after four decades of living in the glacial areas of the Făgăraș, Rodna and Retezat Mountains, Romania

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Abstract

Aim : To highlight the situation of the alpine marmot (*Marmota marmota*) after four decades of colonisation in three mountain ranges of Romania: the Făgăraș, Rodna and Retezat.

Methodology : To reach this target, summer field investigations have been conducted in various areas of the three mountain ranges, and in the archives of central and local forest and hunting administrative units, with a view to identify the data needed to establish the dynamics of these populations.

Results : A synthesis study has been made to point out the population dynamics of this rodent (Sciuridae Family), the connection between populations and the geographical conditions in the glacial areas of the three mountain groups of the Eastern and Southern Carpathians.

Interpretation : A typical rodent of the Alpine regions, the alpine marmots are perfectly integrated in their new habitats with several colonies of these populations in each mountain group. At the same time, the species has extended its areas by up to 20 km.

Introduction

A rodent mammal, *Marmota marmota* lives in the alpine habitats of the highest mountains in Europe (Pyrenees, Alps and Carpathians). The mammal belongs to Order : Rodentia Bodwich, 1821; Family : Sciuridae Gray, 1821 and Genus : *Marmota* Blumenbach, 1779 (Wilson and Reeder, 1993).

Studies performed in the Tatra Mountains (Bačkor 2009), Rodna Mountains (Szabo, 2010), the French and Italian Alps (Allainé *et al.*, 1994; Borgo, 2003) and the Pyrenees (Herrero *et al.*, 1994) revealed significant information on species current distribution, dynamics and habitat requirements in the mountainous areas of Europe.

In Romania, *Marmota marmota* was introduced to the tallest Romanian Carpathians, which is, Făgăraş and Retezat (Southern Carpathians) and Rodna (Eastern Carpathians) (Almăşan, 1981; Geacu, 2006).

As herbaceous species, the alpine marmot feeds on the short plants (*Carex curvula*, *Juncus trifidus*, *Agrostis rupestris*, *Festuca airoides*, *Nardus stricta*, *Sesleria tenuifolia* and *Poa alpina*) that grow in alpine meadows and are well-adapted to cold and strong winds. It also eats the lichens that gnaw on rocks, e.g. *Cetraria islandica* or *Cladonia rangiferina*, and grows at the bark of dwarf bushes such as *Loiseleuria procumbens* of the alpine zone. The alpine marmot also eat the fruits of some species like *Vaccinium myrtillus* and *Vaccinium vitis-idaea*. Alpine marmots are fond of sunny slopes and if nothing disturbs them, they may bathe in the sun for hours on end. Between October to April, the animal hibernates, the entrance to the galleries being closed with stones, grass and earth (Năidăşan, 2000). Moreover, some studies refer to the impact of global climate changes on the shortening of the hibernation period (Inouye *et al.*, 2000, Dolenec and Dolenec, 2011).

It has been considered that the alpine marmot inhabited the highest areas of Rodna, Făgăraş and Retezat Mountains during the 19th century (Bielz, 1888; Csato, 1867), where to it has been disappeared between 1890 and 1900 (Călinescu, 1931; Filipaşcu, 1969). Species' existence in Romania was contested by Rosetti-Bălănescu, (1973) by arguing the absence of any reference to this species in the Romanian folklore or the toponymy of this space (Benedek, 2014). However, a proposal for having the species reintroduced in Romania dates back to 1949, but it was only in 1965, when Almăşan stressed upon the « need to begin acting to this end as soon as possible » (p. 12), that their future habitat (Făgăraş and Retezat Mountains) was being designated (Almăşan, 1965). The first 50 alpine marmot individuals were brought into Romania in 1973, having been captured in the Alps. Out of the 33 animals caught in the Vanoise National Park (France), 21 were released in the Făgăraş Mountains and 12 in the Rodna Mountains. A number of 17 individuals came from Salzburg region (Austria) and were released in the Retezat Mountains (Fig. 1A, Fig. 1B).

The current paper focuses on the analysis of the spatial and temporal dynamics of *Marmota marmota* in the three aforementioned areas in close connection with their habitat requirements and the conservation regime. The study was carried out for the past four decades, a period which followed species' introduction or re-introduction in the fauna of the Romanian Carpathians using the data provided by the Romanian Forest Divisions which overlapped Rodna, Făgăraş and Retezat Mountains.

Study area : The present study was carried out in three of the highest Romanian Carpathians Mountains: the Făgăraş and Retezat in the Southern Carpathians and the Rodna Mountains in the Eastern Carpathians (Fig. 1B), all being built predominantly of crystalline schists (Niculescu and Badea, 2006). They have the most impressive glacial relief (glacial cirques and valleys) of all mountain ranges in this country (Niculescu *et al.*, 1973). Springs on slopes and glacial lakes represent water sources for the alpine marmot.

Materials and Methods

At the time the first alpine marmots were brought into Romania, the researches were focused primarily on identifying the first documents issued by various forestry and cynegetic institutions. Later on, studies performed in the selected case-studies aimed at establishing the population dynamics and species habitat characteristics. The assessment of long-term dynamics relied on the data recorded by the rangers of the Forest Divisions in the analysed mountain areas. Thereby, in 2011 and 2012 the authors carried out direct field observations in the areas where alpine marmots used to live during summertime. Based on the visual observations (using binoculars) conducted during the field surveys, the authors were able to map several alpine marmot habitats and movement routes.

Results and Discussion

The Făgăraş Mountains : The Făgăraş Mountains covers approximately 1,500 km² with a dominant altitude of 2,400-2,500 m a.s.l., favouring the development of alpine and subalpine levels. Likewise, the massif features a significant glacial relief inherited also from periglacial processes of extensive spatial dynamic (Voiculescu, 2002; Voiculescu and Ardelean, 2012). It also preserves the widest glacial area in Romania, especially on the main summit which is about 70 km long from west to east, with maximum elevation in the country: the Moldoveanu (2,544 m a.s.l.) and the Negoiu (2,535 m a.s.l.) peaks. Here, one may see complex glacial cirques, up to 8 km-long glacial valleys and 25 glacial lakes (e.g. Lacul Doamnei – Lake of the Lady 0.5 ha and Podrăgel Lake – 0.7 ha lie at 1,860 m a.s.l. and 2,030 m a.s.l., respectively) (Niculescu, 1973; Velcea and Popova, 1987) (Fig. 2).

At Bâlea Lac weather station (2,038 m a.s.l.), the mean annual air temperature is only 0.2°C, with a maximum of 8.8°C in

August and a minimum of -8.4°C in February (Fig. 3A); the mean annual rainfall reaches 1215 mm (Sandu *et al.*, 2008). The dominant winds blow from the north (21.1%) (Voiculescu, 2002). The annual number of days with snow cover is 150, except for the summer and the first half of winter when no such days are registered (Fig. 3B).

The habitat conditions of the upper Făgăraş Mountains are favourable to the alpine marmot. The species was introduced in the area in July 1973, when 21 alpine marmots were brought from the French Alps and were released in the glacial cirque at the sources of the Arpăşel Valley (northern slope of Făgăraş Mountains, Sibiu County). Here, the staff of the Arpaş Forest Range built man-made galleries in order to host them and prohibited the grazing of farm animals. This action enjoyed the support of the Inspection for the Economy of Hunting of the Ministry of Forest Economy and Building Materials (Almăşan, 1981). At the beginning, the alpine marmots settled at 1,900–2,000 m a.s.l., subsequently extending their area at higher elevations. The animals soon left the man-made galleries, digging themselves others in the source area of the Arpăşel Valley. In 1981, their number had increased to some 100 individuals in the Arpăşel glacial cirque. The locals would name the place "Alpine Marmot Hollow" (Almăşan, 1981).

By the end of 1980, the animals expanded their area eastwards in the eastern sector of Făgăraş Mountains (Braşov County); in 1989, about 40 specimens were found to live there. Overall, in the Făgăraş Mountains, 100 individuals were signalled in 1989 of which 65 remained in 1991 and around 70 in 1993. Consequently, the alpine marmots shifted to the southern slopes, extending their habitat towards west (up to 9 km as far as the glacial cirques of Negoiu and Şerbota peaks) and east (e.g. towards the Podrăgel glacial cirque). In 2005, the Făgăraş Mountains held 240 specimens of which 190 on the northern slopes (115 in Sibiu County and 75 in Braşov County) and 50 on the southern slopes (Argeş County). As a matter of fact, the first alpine marmots were introduced in Sibiu County, but very near to its boundaries with Braşov and Argeş counties. Apart from Arpăşel glacial cirque, specimens could be seen also in the glacial cirques Albota, Arpăşelul Mare, Şerbota, Doamnei, Podrăgelul, Laiţa and Târla Mare. In 2014, this mountain sector held 373 individuals (57.6% in Sibiu County, 27.9% in Braşov County and 14.5% in Argeş County), 85.5% of the observed individuals are found on the northern slope.

The Retezat Mountains : The Retezat Mountains are situated on the west side of the Southern Carpathians. The highest peaks are Peleaga (2,509 m a.s.l.), Retezat (2,482 m a.s.l.) and Bucura (2,433 m a.s.l.). The whole area extends over 453 km², but the alpine relief (above 1,800 m) represents 27% of the surface (Urdea, 2001). In the central part of the Retezat Mountains, the main landscape features are shaped by the glacial relief which consists of rocky peaks and crests, huge glacial cirques with vast screes, and glacial valleys (Niculescu, 1973; Urdea, 2000) (Fig. 4).

Outstanding among the 58 glacial lakes are Bucura (10 ha), Zănoaga (29 m, the deepest glacial lake in Romania) and Gemenele (2.5 ha) (Pişota, 1971; Gâştescu, 1971; Popovici, 1993). At Ţarcu weather station (2,180 m a.s.l.), situated in the neighbouring mountain sector, the mean annual air temperature is negative (-0.6°C), with a maximum value in August (7.7°C) and a minimum in February (-8.6°C) (Fig. 5A). The mean annual precipitation sums up to 939.4 mm. The dominant wind blows from the north (21.5%) and the snow cover may appear in the first decade of September and it lasts until July or August (Fig. 5B). The annual number of days with snow cover was 190 days on average (Dragne *et al.*, 2004).

The upper part of the Retezat Mountains was established in 1935 as the first national park in Romania (10,000 ha). Currently, the surface of this protected area has been extended to 38,047 ha, of which 1,630 ha is covered by Gemenele Scientific Reserve. In 1973, 17 alpine marmots, brought from the Austrian Alps, were released in Gemenele Scientific Reserve, the endeavour being supported by the Commission for the Monuments of Nature of the Romanian Academy, and by the Strasbourg-based European Council of Information for Nature Protection. Shortly after, all the individuals introduced at the site named « Faţa Retezatului » (The Retezat Frontface) moved to the Bucura glacial cirque (the homonymous lake lying at 2,041 m a.s.l.), because of a *Vipera berus* reptile, whose bite is fatal for the alpine marmot (Almăşan *et al.*, 1986). Later, on, the species would expand its territory in the neighbourhood, namely the Gemenele glacial cirque, and also in the vicinity of the lakes Ştirbu, Tăul Agăţat and Tăul Negru.

Field surveys and scientific literature (Almăşan, 1986; Benedek, 2006) revealed that glacial cirques are the favourite habitats for the alpine marmots. The main glacial lakes in the Retezat Mountains in the surrounding of which alpine marmots were observed is described in the Table 1 (Gâştescu, 1971).

Numerous specimens occurred in the glacial cirque that hosts lakes Bucura, Ana and Lia. In 1978, alpine marmots were seen at 2,200 m a.s.l. below the Slăveiu Mare Peak (2,346 m a.s.l.); in 1980, they were found roamed in Judele Mount, too (2,398 m a.s.l.), but also near the Tăul Ascuns Lake. In 1981, the

Table 1 : Main characteristics of some glacial lakes in the Retezat Mountains (Gâştescu, 1971)

No.	Lake	Surface (ha)	Altitude (m a.s.l.)
1.	Bucura	8.9	2,041
2.	Gemenele	2.5	1,900
3.	Tăul Negru	4.0	2,025
4.	Ana	3.1	1,979
5.	Lia	1.3	1,930
6.	Ştirbu	0.9	2,090
7.	Tăul Ascuns	0.4	2,180
8.	Tăul Agăţat	0.1	2,208

Fig. 3 : (A) Monthly variation of air temperature and (B) number of snow cover days at Bălea Lac weather station (1961-2000)

Fig. 4 : Glacial relief in the Retezat Mountains (source: Niculescu, 1973, map modified by the authors)

Retezat Mountains held about 100 individuals, 77 in 1985, 140 in 1989 and 100 in 1992. In 2005, a number of 200 alpine marmots were recorded, while in 2014 increased upto 224.

The Rodna Mountains are the highest mountains in the area located in the northern part of the Eastern Romanian Carpathians. Because of their high altitude, the Rodna Mountains are affected by the Quaternary glaciations featuring one of the most imposing alpine landscapes in the Romanian Carpathians with best preserved glacial and periglacial landforms (Dragotă

and Kucsicsa, 2011; Kucsicsa, 2013). The glacial topography includes glacial cirques (the Pietrosu, Buhăiescu, Repede, Negoiescu, Cimpioiesei, Bistriței Aorii, Ineu and Lala), moraines (in the Lala, Bila, Putredu and Bistricioara valleys), erratic blocks and glacial valleys (Fig. 6).

The number of glacial lakes, which lie behind some moraine deposits, is around 30. They are located between 1,750 m a.s.l and 1,950 m a.s.l (Gâștescu 1971; Kucsicsa 2013), over a surface-area under 0.5 ha and maximum depth of 5.2 m (Buhăiescu II Lake) (Chiș, 2010). In the alpine area, the mean

Fig. 5 : (A) Monthly variation of air temperature and (B) number of snow cover days at Țarcu weather station (1961-2000)

Fig. 6 : Glacial relief in the Rodna Mountains (source: Kucsicsa, 2013, map modified by the authors)

annual air temperature is negative (-1.3°C at over 2,300 m a.s.l.), but at Iezer weather station (1,770 m a.s.l.) the annual average temperature is 1.5°C (Kucsicsa, 2013; Chiş, 2010). The monthly mean temperature is negative between November and March (Fig. 7A). The mean annual precipitation is 1263 mm.

Snow cover may appear in the first decade of September and last until July or August (Fig. 7B). The annual number of days with snow cover was 175 days on average (Dragne *et al.*, 2004; Kucsicsa, 2013). The dominant winds (15%) blow from the south-west speeding up with $3.5\text{--}4.5\text{ msec}^{-1}$ on average (Kucsicsa, 2013).

The Rodna Mountains stands as the only west-east ridge (20 km long) that still preserves traces of Quaternary glaciation, which has high population of alpine marmots. The animals were released close to the tallest peak: Pietrosu (2,303 m a.s.l.). Where glacial cirques and valleys, as well as 30 glacial lakes are present. In 1973, shortly after the species had been introduced in the Făgăraş Mountains, 12 individuals from the same batch originating in the French Alps were released on the south/south-west slope of Mount Pietrosu (Almăşan, 1981) inside Pietrosu Mare Reserve created in 1962 and given a Biosphere Reserve status in 1979 (Bălţeanu *et al.*, 2006). This

Fig. 7 : (A) Monthly variation of air temperature and (B) number of snow cover days at Iezer weather station (1961-2000)

Fig. 8 : Alpine marmot population dynamics in the three Romanian Carpathian ranges (1973-2014)

development benefitted from the support of the former Bucharest-based Inspection for Game Economy.

In the beginning, Reserve guards would build the animal galleries. But, introducing, species introduction was considered to be a failed attempt given that the galleries had been deserted. However, two years later, in 1975, a first alpine marmot colony was detected at some distance (from the early place of release), namely in Zănoaga Mare glacial cirque on the northern side of Mount Pietrosu (Pânzariu, 1993). It appeared that the alpine marmots had settled from 1,700, m a.s.l. (the initial introduction site) to 1,800-2,000 m, some individuals were observed at 2,200 m a.s.l.

In June 1977, the species extended its territory eastwards, to Bistrița-Năsăud County, alpine marmots being seen in the direction of Gărgălaș Mount (2,159 m a.s.l.). In 1980, the Rodna Mountains alpine marmots numbered 60 individuals (grouped into 8 colonies), the population nearly doubling till 1983. In 1989, they counted 130 individuals (120 specimens in the Maramureș County sector and only 10 in Bistrița-Năsăud). The year 1992 registered 180 alpine marmots, 165 in Maramureș and 15 in Bistrița-Năsăud County.

In 1993, some individuals were signalled out east of the Puzdrele Peak (2,191 m a.s.l.), in the Negoiescu Valley. In 1999, the Rodna Mountains alpine level numbered 180 specimens and

around 210 in 2005. Most entrances are oriented to the East, South, South-East and South-West (Szabo, 2010). In 2011, 150 specimens were observed, all of them on northern slopes in Maramureş County.

The species was seen in the glacial cirques Zănoaga Mare, Iezer and Buhăescu, in the Pietrosu Mare and Piatra Neagră mountains, reaching as far as Gărgălău Mount to the east. The guards of the Rodna Mountains National Park name Zănoaga Mare glacial cirque « The Marmot Pit ». The expansion of the species' area towards the Corongiș (1,987 m a.s.l.) and Ineu (2,279 m a.s.l.) Mountains, which means by some 20 km east was reported (Kucsicsa, 2013). In addition, the presence of marmots was also indicated in the surrounding areas, in the north-bordering Maramureş Mountains, more precisely just below the Toroioaga Peak (1,930 m a.s.l.) situated towards the southern end (Nădișan, 2000).

The life of these animals (very fond of quiet) was disturbed by grazing and tourism, some of them being occasionally killed, e.g. one in 1977 by shepherd dogs close to Buhăescu Lake, and another in 1978 near the Gărgălău Peak (both in the Rodna Mountains).

Although proposals for the introduction of this species in Romania's fauna had been made as early as 1949, it was only in 1965 that the Făgăraș and the Retezat mountains were chosen as population sites. In the early 1970s some would suggest the Rodna Mountains, as well.

Despite the fact that galleries to shelter them had been built in all the three massifs, the alpine marmots quickly deserted them, digging themselves new ones, closer to, or remoter from those made by man, the new environment was seemingly better and more propitious.

The alpine marmot sites are shared also with the chamois (*Rupicapra rupicapra*) and although both species are herbivorous, yet the wealth of food makes them live in ecological « harmony », as it were. Thereby, in case of danger, alpine marmots would warn the chamois of an enemy approach by emitting more sonorous and powerful signals than the latter do.

The three populations introduced in 1973 increased fifteen times over the last four decades, from 50 to 747 individuals, namely 50% in Rodna, 30% in Retezat and 20% in Făgăraș mountains (Fig. 8).

A typical alpine rodent, the alpine marmot got perfectly integrated into the new habitats of alpine landforms and alpine meadows of the three mountain zones, each mountain range hosting several alpine marmot colonies. They would extend their areas (up to 20 km) in other favourable zones, most often being seen in the screes adjoining the alpine meadows where they found shelter and food.

Newly reintroduced in the Carpathian Mountains, and in Romania for that matter, alpine marmots have been protected all along in the Retezat Mountains National Park, the Pietrosul Rodnei Nature Reserve and Arpășelului Valley Nature Reserve, the first sites of their release. Under Law No. 13, 1993 on Romania's adherence to the Convention for the Conservation of Wildlife and Natural Habitats, adopted in Bern in 1979, the alpine marmot becomes a protected animal. Thus, alpine marmot areas in the Retezat and the Rodna Mountains are nowadays part of the homonymous National Parks established in 1935 and 1990, respectively (Buza *et al.*, 2005). Protection of the alpine marmot species is stipulated also by Law No. 462, 2001, on the regime of protected areas and conservation of natural habitats, of wild flora and fauna.

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