

COLONIZATION PROCESS OF THE ALPINE MARMOT (*Marmota marmota*) IN SPANISH WESTERN PYRENEES¹

POR

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SUMMARY.—Colonization process of the Alpine marmot (*Marmota marmota*), its present distribution and probable evolution in Northern Aragon (Spain) is described. Main human and physical factors that seem to determine this distribution process are discussed: spatial and temporal localization of introductions in the French slope, human presence and relief (ie. high massifs, steep slopes, valleys, mountain passes, main southern exposures and microtopography).

RESUMEN.—Se describe el hipotético proceso colonizador de la marmota en Aragón, el estado actual de su distribución y su previsible evolución. Se detallan asimismo los principales factores físicos y humanos que parecen determinar este proceso distributivo: localización espacio-temporal y frecuencia de las sueltas en la vertiente francesa, presencia humana y relieve (macizos elevados, pendientes abruptas, valles, collados, predominio de exposiciones Sur y microtopografía).

RESUME.—On décrit la progression hypothétique du peuplement de la marmotte alpine dans les Pyrénées aragonais, sa distribution actuelle et sa possible evolution future. Aussi on détaille les principaux facteurs physiques et humaines qui semblent conditionner cette période de colonisation, c'est à dire: la localisation espace-temporaire et la fréquence du lâchers dans le versant française, les dérangements causés par diverses activités humaines et les caractéristiques du relief (chaines montagnaises élevées, pressence de cols au dessous de 2.400 mètres et dominance des expositions Sud, entre autres).

Key-words: Marmot, colonization, aragonese Pyrenees.

¹ Received May, 1988.

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1. Introduction

The Alpine marmot (*Marmota marmota*) is at present time widely spread all through the Aragonese Pyrenees, because of the repeated introductions carried out in the French slope of the mountain chain since 1948 (COUTURIER, 1955; BESSON, 1971). Any known introduction was carried out in Spain.

Occupied area extends continuously along the southern watershed from Belagua, on the Oriental edge of Navarre, to the Sierra dels Canals in Lleida (Catalonia). Other isolated localities appear further East in the Sierra de la Vellela and in Nuria.

The habitat of the marmot in the Aragonese Pyrenees is the rocky pastures between 1.600 and 2.400 m. high, mainly oriented southwards and with an easily tunneled soil, as happens in the same way in the Alps (MÜNCH, 1958) and in the French Pyrenees. In the Northern Pyrenees slope, JEAN (1979) and PELLIZZARI *et al.*, (1982) add as characteristic elements of the habitat the forest distance, quietness and great visibility.

The marmot's large scale distribution in the Spanish Pyrenees was already described in a previous note (GARCÍA-GONZÁLEZ *et al.*, 1985). New data collected on old and present colonies in the study area enable us to describe the hypothetical colonization process of this high mountain rodent in Aragon.

2. Methods

Colonies citations of the Spanish slope were obtained from sampling data, inquiries to the guards of ICONA and COMENA, information from the highlanders and bibliographic research. JEAN'S (1979) Doctoral Thesis based on Western Pyrenees National Park documentation, has provided information on the known introductions in France and also on some of the first colonies in Spain (see Annex).

Figure 1 represents introductions in France and citations of Spanish colonies grouped by decades. Some colonies of the eighties have been omitted to simplify map comprehension. In the Annex, a complete list of compiled localities is given. 1.600 and 2.400's meters elevation lines have been introduced on the map coinciding with customary altitudinal range of Pyrenean marmot.

3. Colonization process

The introductions on the French slope have been numerous and frequent, specially during the sixties and the seventies. Some freeings

were repeated for several years in the same area. These periods are indicated in fig. 1. Only official introductions are represented, even though other non-official introductions were also carried out.

Environmental heterogeneity in the Spanish slope and the introductions policy carried out in France motivated a peculiar colonization, according to the singularity of each valley or massif. Thus, a detailed description of the process in a small geographical scale is necessary.

Veral-Subordán watershed. Settlement has been recently initiated. First data arise from the eighties. This delay is due both to the scarce introductions in France and to the small success of some of them: in the Pic d'Anie, the introduced marmots disappeared after the freeing JEAN (1979)*. Actual presence in Belagua is probably due to a migration from the contiguous valley of Veral, rather than from France, from which is separated by the karstic massif of Larra. This landscape does not seem to offer suitable habitat conditions for the species. At the present, this is the westernmost citation of this rodent.

Bisaurín massif and Sierra de Aisa. The great number of introductions on the French slope since 1970, due to the creation of the Western Pyrennes National Park (BESSON, 1971), and the easy approach from the North through mountain passes (Palo, Estanés, Bernera) less than 2000 m high made possible the settlement of the colonies in Spain since the seventies. Further citations in the eighties show the expansion of the colonized area and the increase of the number of colonies.

Aragón-Gállego watershed. In spite of the great extension of the area, the easy approach from France and the great number of early introductions, marmots are very scarce, nevertheless the first colonies settled in the seventies. This situation may be justified by the disturbing human activities, such as important roads (Somport and Portalet mountain passes), mining activities, ski resort building during the last decade and strong tourist pressure.

Gállego-Ara watershed. First citation goes back to 1968. This early colonization is probably due to the early (1954) and frequent French introductions and to the facility in crossing the boundary. Mountain passes such as Bujaruelo (2.257 m.) and Bernatuero (2.336 m.) are the natural border passes in an area with high massifs and steep slopes. During the seventies, the distributional area increased to the South and to the West, reaching the western part of the divide probably through Tendeñera pass. The great height of the frontier massifs delayed the colonization in the northwestern area (Balaitus and Panticosa cirque). There is no evidence of them up to the present decade. Migration routes are unknown, but presumably the flow into this region was from

* Besson (pers. comn.) reported us their existence in the Col des Anies (June, 1988).

France, through San Martín pass, although migrations could also have come from settled colonies of Tendeñera massif or from Ferraturas.

Arazas valley. The change of divide was probably through Bujaruelo pass. Great orographic difficulties such as height and steep slope in the Taillón-Mondarruego axis determined a scarce and recent presence (1985).

High Cinca basin. Early freeings on French slope (1948) determined the colonization of Pineta and Bielsa valleys since the late sixties. The border was probably crossed through Puerto Viejo pass (2590 m). Steep slopes and high elevation of treeline in both valley headwaters reduce marmot habitat. This seems to have determined a high-altitude spread to the East along the mountain range axis. Delayed presence in Gistain valley corresponds to the lack of introductions in France and to the great heights that separate both slopes. Expansion in the valley is presumably due to the migrations from the West side of the basin, through Ordiceto pass, and from the East across Gistain mountain pass (2595 m).

Esera valley. The first introductions in France correspond with early spread on the Spanish slope, in the late sixties. In spite of the rough orography of the divide, this early colonization might be due to the situation of the mountain passes of Benasque (2410 m) and Gurgutes (2367 m). They are the natural mountain passes across the watershed in the area. Consecutive freeings made near the border during the seventies helped the settlement process in the southern slope. Introductions in France do not seem to have succeeded (JEAN, 1979). It shows the importance of exposure with a southern component as a preferential habitat of this rodent (BOPP, 1954; PIGOZZI, 1984). The spread in the valley followed presumably two directions: one to the West, following the mountain range as far as Estós valley; another to the East, surrounding Maladeta massif. This late dispersal reached Sierra Negra which is the eastern citation of the study area and the southernmost of the species at the present*.

The Inner Sierras. In the whole study area, this mountainous system extends from Peña Forca and the Alanos massif as far as the Turbón one (SOLÉ-SABARIS, 1951; SOLER AND PUIGDEFÁBREGAS, 1970). They represent a limestone axis with an East-West orientation, which has been a temporary barrier to the expansion process of marmot. This limitation has been stronger wherever the Sierras were more abrupt and more distant from the border. The occidental massifs are small and near to France. This has enabled marmots to cross them without great difficulties. A great number of colonies settled on their southern slope. The central and oriental areas, which represent a bigger massif, delayed

* The southernmost dubious citation of Basibé col has been recently confirmed by one of the authors (August 1988).

spread in southern direction. Tendeñera-Taillón-Tres Sorores axis is where the barrier effect of this Sierras is clearest. Other central and oriental massifs (Collarada, Peña Telera, Cotiella) presumably have not been reached yet. Their distance and orographic conformation may represent a barrier for the colonization of the southern slopes.

Progression. The process achieved by the marmot allows us to believe in the increase of their actual distributional area. New massifs with no confirmed citations will be colonized and already occupied areas will be more densely inhabited. Accordingly, future expanding directions are indicated in fig. 1 with discontinuous arrows.

4. Factors determining expansion

Motivations of rodent dispersal are not yet convincingly known. The process is determined as a result of demographic pressure and genetic factors (LIDICKER, 1975).

Analysis of past and present distribution of the marmot in the Spanish slope allows us to deduce which have been the physical and human factors determining their spreading in Aragon:

Temporal and spatial distance to the French introductions and their frequency. Spanish colonies with an earlier settlement correspond to French areas where freeings have been nearer and/or more frequent.

TABLE 1

Influence of main environmental factors upon colonization in the studied areas

Area	I	II	III	IV
Veral-Subordán watershed	—	+		Low
Bisaurín massif and Sierra de Aisa	+	+		High
Aragón-Gállego watershed	+	+	—	Low
Gállego-Ara watershed	+	—		High
Arazas valley		—	—	Low
Cinca's high basin	—	—		Low
Ésera valley	+	—		Medium

I: Intesity of French introductions.

II: Topography.

III: Human disturbance.

IV: Present density.

+: Favouring colonization factor.

—: Unfavourable colonization factor.

Absence of symbol: Indifferent action of the factor.

Relief. High massifs or with abrupt slopes delay but do not prevent dispersal. They act as orographic barriers. Valleys, on the contrary, channelize migrational flow. Mountain passes are important paths for the colonization of new areas, specially the ones below 2400 m. Habitat selection is an essential factor in the occupation of a territory. Predominantly sunny exposures are a significant habitat factor for the marmot. In this sense, environmental conditions are less suitable on the Northern slope and this helped expansion on the Southern slope. Finally, microtopography can influence dispersal movements conditioning, on a small scale, the colonization process.

Human activities. Man's activities and infrastructure development are a great difficulty for the colonies settlement, as happens in the French Pyrenees (JEAN, 1979) and in the Alps (TOSCHI, 1954; SPAGNESI *et al.*, 1979).

The positive or negative influence of the above mentioned factors on the colonization process of the different topographic units has been summarized in table 1. Absence of symbol indicates factor's indifference to the colonization process of the area. Generally presence of one or many negative signs in a certain area determines an actual low density settlement.

Peculiarity of each occupied valley and looses dates have determined an heterogeneous spread, although coherent with the environmental factors examined. Conjunction of both characteristics (heterogeneity and coherence) shows the colonization process dynamics in the Spanish Pyrenees slope during the last twenty years.

Acknowledgements. We thank for their collaboration: guards of ICONA and COMENA, researchers of the Instituto Pirenaico de Ecología and staff of the Western Pyrenees National Park and of other research and wildlife management centres, shepherds, highlanders and friends. Their help and interest in the mountains made this work possible. We also thank Dr. J. Gosálbez and J. P. Besson for critical revision of the manuscript. This study has been supported by CSIC program n.º 4-608-1 ID609 "MONTAÑA".

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Annex

Localities with marmot colonies, used in this study. Year of observation shown in brackets. Citations with an asterisk correspon to an unpublished inquiry of ICONA in 1978. Dates marked with a cross belong to JEAN (1979). Question mark indicates dubious information. The remaining citations were obtained or furnished to the authors.

Roncal valley (Esca river): Collado de Larrería (1985).

Ansó valley (Veral river): Hoya de la Solana (1985), Petrechema (1985).

Echo valley (Aragón Subordán river): Foya de Gamueta (1986), Barranco de Acherito (1986), Puerto del Palo-Las Foyas (1985), Mallo Blanco (1986), Aguas Tuertas (1976*, ≤ 1984), Pic d'Arri (1973*), Castillo de Acher (≤ 1984, 1986), Barranco de Agüerri (≤ 1984, 1986), Tacheras (1986), Collado de Foratón (1984), Secús (1978*, 1986), Boca del Infierno (≤ 1984).

Aragüés valley (Osia river): Llano Lizara (1986), Foratón (≤ 1984), area between Lizara and Plano Mistresa (1985), Plano Mistresa (1978*), Bisaurín Mountain foot (≤ 1984), Valle de los Sarrios (1979, 1985), Circo de Olibón (1978*), Bernera (1978*, 1986), Los Costallones (1985).

Aisa valley (Estarrún river): Cubilar del Tuerto (1985, 1987), Ibón de Izagra (1985), Ruabe de Bernera (1985), Val del Bozo (≤ 1984 , 1985), Barranco de Aspe (1986), Peña Verde Mountain foot ($\leq 1978^*$, 1985), El Cubilar (1985), Igüer watering place (1985), Rigüelo (1981, 1984, 1985, 1986), Garganta de Aisa ($\leq 1978^*$, 1982, 1985).

Canfranc valley (Aragón river): Gabardito (1985), Candanchú (1978*, ≤ 1984), Canal Roya ($\leq 1984^?$), Col des Moines (France, 1978*), Col Mayou (France, 1974*, 1975*).

Tena valley (Gállego river): Portalet (1984), Anayet (1978*), Barranco de Espelunciecha (1984), Barranco de Culivillas (1984), El Petruso (1984), Ferraturas ($\leq 1978^*$, 1984), Llano Cheto (1985), Lagos de Arriel (1977*, 1985), Passe de la Barane (1977*), Respumoso reservoir (1981, 1984), Barranco de Respumoso (1984, 1986), Port d'Azun (France, 1974*), Ibón de Tebarray (1984), Ibón de las Salvas (1987), Ibón de Bachimaña (1984), Panticosa health resort (1984, 1985), Yenefrito ($\leq 1978^*$, 1983), Ripera river (1983, 1985), Montaña El Verde ($\leq 1978^*$, 1983), Sabocos (1983, 1984), Ibón de los Asnos (1983, 1984, 1986), Collado de Tendeñera ($\leq 1978^*$, 1983, 1984), Puerto de Ordiso ($\leq 1978^*$, 1983).

Torla valley (Ara and Arazas rivers): Suaso-Linás ($\leq 1978^*$), El Cebollar ($\leq 1978^*$, 1985), Otal (1968, $\leq 1978^*$, 1985), Barranco de Sandaruelo ($\leq 1978^*$, 1985), Bujaruelo (1984, 1985), Viñamala mountain foot (1983), La Catuarta (1985), Cotatuero (1985).

Bielsa valley (Cinca and Barrosa rivers): La Larri - Puerto Viejo - Tormacal (1968*, 1976*, 1985), Fuen Santa - La Estiba (1976*, 1985), Espierba (1986), Barrosa Cirque (1968, $\leq 1978^*$, 1985), Trigoniero (1985), Ordiceto (1983, 1985).

Gistain valley (Cinqueta river): Puerto de la Pez (1985), Puerto de la Madera (1985).

Benasque valley (Ésera river): Eriste valley (1985?), Estós valley (1985), Peña de Literola (1985), Molseret ($\leq 1978^*$), Remuñe (1979, 1982), Gurgutes ($\leq 1978^*$), Fuens Royas ($\leq 1978^*$, 1985), La Costera (1967*, 1978*), Alba valley ($\leq 1979^*$), Ibón de Paderna, (1982), Pico de la Renclusa (1985), southern part of Aneto (1985?), Sierra Negra (1985), Llauset (1985?), Collado de Basibé (1988).

