Transhumant GPS tracked sheep flocks from lowlands to highlands in Spain: grazing resources use and difficulties of walking/herding

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Abstract. The need for preserving walking/herding transhumance drove roads on the Iberian Peninsula has been widely recognized, as they provide a wide range of ecosystem services. In spite of the decline of walking transhumance in Spain, some drove roads are being reactivated due mainly to the high price of lorry transport and feeds for livestock. The objectives of this work were: (i) develop a method to track the transhumant flocks in order to know the route followed and detail the type of pastures that the sheep use during the trip; (ii) know the main difficulties of the activity, either technical, economic or social. Collars with GPS were installed around the neck of some animals of five transhumant flocks. The data provided by GPS were analyzed by a GIS and overlapped with pastures/vegetation maps. For each flock, interviews with the farmers provided data in terms of difficulties for the activity to be continued. The method provided highly accurate data of the routes. The main types of vegetation used by sheep and main difficulties perceived by the farmers to continue the activity are summarized.

Keywords. Drove roads – "Cañadas" – GPS tracking – Vegetation use.

Suivi par GPS des troupeaux ovins transhumants du plain à la montagne en Espagne: utilisation des ressources fourragères et difficultés du déplacement à pied

Résumé. *La nécessité de préserver les drailles ou chemins de la transhumance à pied dans la péninsule Ibérique est largement reconnue, parce qu'elle fournit une grande diversité des services des écosystèmes. Malgré la diminution de la transhumance à pied en Espagne, quelques chemins de la transhumance sont une nouvelle fois utilisés á cause, surtout, de l'augmentation des prix des inputs dans les exploitations, comme le coût des camions et de l'alimentation. Les objectifs du travail sont: (i) développer un système de suivi des troupeaux pour connaitre l'itinéraire suivi et les types de végétation pâturée par les troupeaux pendant leur déplacement; (ii) connaître les principales difficultés du point de vue technique, économique et social de cette pratique. On a mis des colliers de repérage GPS dans le cou des plusieurs brebis dans chacun des cinq troupeaux transhumants étudiés. Les données fournies par le GPS ont été analysé à travers du SIG et ont été superposé avec des cartes de végétation. On a aussi réalisé des enquêtes aux éleveurs pour obtenir information sur les défis pour la continuité de la transhumance à pied. La méthode utilisée a fourni des données très précises des itinéraires suivis. Les principaux types de végétation pâturée par les troupeaux ainsi que les principales difficultés ont été résumé.*

Mots-clés. *Drailles – « Cañadas » – Suivi par GPS – Utilisation végétation.*

I – Introduction

Transhumance is a livestock production system that avoids the critical periods of plant production by means of seasonal moving of livestock, and follows the same routes (drove roads or 'cañadas' in Spain, 'cabañeras' in Aragon) every year.

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Many studies have highlighted the wide range of ecosystem services provided by the walking/herding transhumance, including ecological connectivity, seed dispersion, soil fertility, fire prevention, maintenance of cultural landscapes, biodiversity conservation, and traditional ecological knowledge (e.g., Gómez Sal and Lorente, 2004; Oteros-Rozas *et al.*, 2013; Ferrer, 2016). The abandonment of drove roads and winter and summer grasslands leads to an increasing of fire risk, biodiversity losses and landscape homogenization.

In Spain, sheep transhumance by walking/herding had high relevance until the nineteenth century and almost disappeared in the 1970s-1980s. At present, some of the main roads are being re-activated by foot transhumances, mainly because of the increase of input prices such as fuel for transportation in lorries, and price feeds.

Difficulties and conflicts of the walking transhumances have been identified in some drove roads, such as intrusions of crops, paved roads, residential areas, golf courses, dumping sites, etc. (Pallaruelo, 1993; Oteros-Rozas *et al.*, 2013).

The objectives of the present study were: i) develop a method to track the transhumant flocks in order to know the exact route followed and detail the type of pastures that the sheep use during the trip and ii) assess the main difficulties of the activity, either technical, economic or social.

II – Materials and methods

Five sheep transhumant flocks and routes were studied in the Iberian Peninsula, from the Ebro Basin to the Pyrenees (routes 1 to 4) and from the Iberian Range to the southwest *dehesas*. The characteristics of the routes and transhumant animals are summarized in Table 1.

Table 1. Characteristics of the routes and sheep transhumant flocks

	Route 1	Route 2	Route 3	Route 4	Route 5
Main breeds	Churra Tensina	Crosses x Rasa Aragonesa, Talaverana, etc.	Chisqueta	Rasa Aragonesa	Merina de los Montes Universales
Livestock Units	185	186	168	325	416
Origin – Destination	Huesca – San Juan de Plan	Lascasas – Canfranc	Loscorrales – Zuriza	Loscorrales – Astún	Vilches – Guadalaviar
Lengh (km)/days	126/15	97/6	109/7	80/6	343/22
Biogeographical region		Mediterranean – Alpine			Mediterranean

Collars with GPS were installed around the neck of two animals of each flock, programmed to get positional and temporal information every 30 seconds with an accuracy of 2-5 m. GPS data were analyzed by means of Quantum GIS software and overlapped on a pastures map previously generated by Barrantes *et al.*, (2005) for routes 1 to 4, and on a vegetation map "Mapa Forestal de España" (Ruiz, 1994) for route 5. Proportion of the four major types of pastures in each route and percentage of time spent on each type were calculated for the five routes. Differences between the routes in terms of distribution of the time spent on each type were assessed by means of Chi-Square Tests. Differences between the use of vegetation and proportion of the types were assessed by means of G-tests. Ivlev's electivity index E_i (Jacobs, 1974) was calculated for the five herds in relation to the four major pastures types. $E_i = (r_i - p_i) / (r_i + p_i)$, where r_i = fraction of time spent in vegetation type and p_i = fraction of area covered by vegetation type. E_i takes values between 1 (highly preferred) and -1 (completely avoided). Pastoral Value (PV) of each pastures types was obtained mainly from Reiné *et al.*, 2004 and Maestro *et al.*, 2004, where published phytosociological inventories of each pasture type

were used and PV was calculated using the Daget & Poissonet (1972) method. PV has been used extensively as a pasture quality index to identify potential livestock stocking rates (Loiseau *et al.*, 1998). Kendall's coefficient of rank correlation was used to explore the relationship between PV weighted by proportion of each pasture type and percentage of time spent on each type.

Farmers were interviewed, addressing economic, social and animal production aspects and main difficulties of the activity, only the last results are presented in this work.

III – Results and discussion

The distribution of time spent by the flocks on each type of vegetation (in percentage) was different for every route (Chi-Square Test, P<0.05) except for routes 2 and 5, which showed similar distributions of time (P>0.05). In routes 1, 3 and 4, the flocks spent clearly more time on natural pastures (grazeable forests, shrublands, and natural grasslands) than on arable land and meadows (Fig. 1a). The use of the four types of vegetation deviated significantly from the expected use in terms of proportion of each type (Fig. 1a versus 1b), (P < 0.001 in all routes).
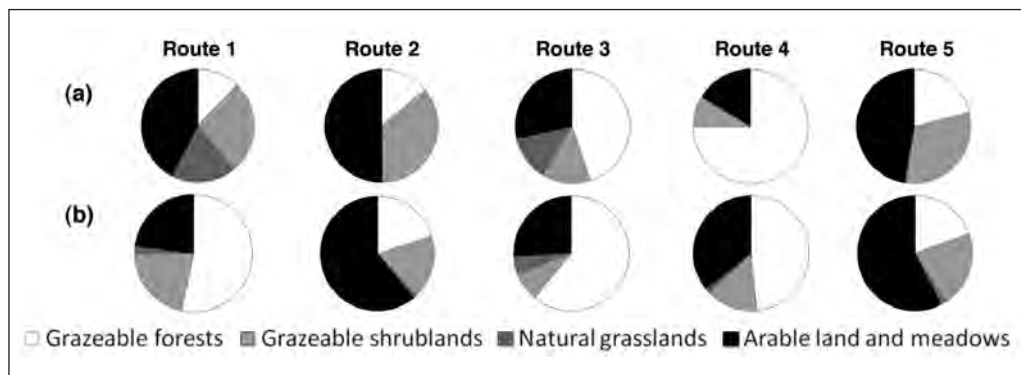

Fig. 1. **(a) Percentage of time spent by five transhumant sheep flocks on different types of pastures. (b) Proportion of each type of pasture.**

Flock of route 1 and 3 had preference by shrublands, natural grasslands, and crops and meadows, and avoided grazeable forests. Flock of route 2 preferred shrublands and avoided the rest of the types. Preferences of flock of route 4 were complementary to those of routes 1 and 3. Flock of route 5 preferred shrublands and avoided natural grasslands and crops (Fig. 2).

The percentage of time spent by the flocks on the types of vegetation was correlated with the Pastoral Value of the vegetation weighed by their availability (t = 0.489, p < 0.001). The value of t suggests that shepherders decisions about the timing of herding is driven also by factors other than quality of pastures like slope, availability of water, planned date of arriving at the destination, etc.

The farmer survey showed some difficulties of herding/walking transhumance that may hinder the continuity of the activity. The main difficulties were (percentage of farmers in brackets): **Physical/technical:** Interruptions of the drove roads (all farmers); shrub encroachment, poor state of conservation of the drove roads, narrowing of the drove roads (80%); tracks not sufficiently labelled (80%); lack of drinking troughs (all farmers). **Social**: lack of continuity linked to ageing of farmers and lack of an appropriate generational turnover (all farmers). **Economic**: no direct subsidies (all farmers). In terms of farmers' perception, animal welfare was not an issue of the walking/herding transhumance.

IV – Conclusions

Flocks used several natural and arable land resources along the routes. Most of the flocks studied spent more time on grazeable forests, shrublands and xerotrophic natural grasslands than on arable land and meadows. There are relevant physical/technical, economic and social difficulties that may threaten the continuity of the activity. The method developed to track the flock was suitable for the objectives of the study, providing highly accurate data of the route.
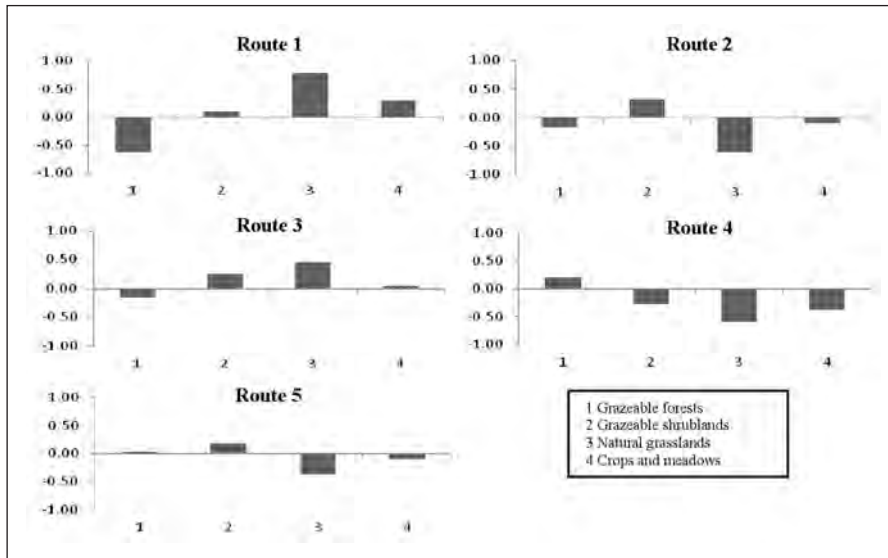

Fig. 2. Ivlev's electivity index for the five transhumant herds in relation to the four major vegetation types.

Acknowledgments

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