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Recording and mapping traditional transhumance routes in the South-Western Macedonia, Greece

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Abstract Transhumance is an animal husbandry system dating back many centuries. Seasonal movement of people and their livestock within the framework of this system follows predetermined routes and area-specific practices. This paper deals with the recording and illustrating of these routes for the first time in Greece where no official records available. The aim is to reveal both their historical importance and their relevance to modern herders. With the assistance of historical cartography and geographic information systems, a geodatabase was created for storing data relating to movement in the geographical space. At the same time, transhumance routes were accurately depicted on digital maps. As a result, verbal and written information on this traditional practice was effectively organized and stored, and the seasonal movement of people and their livestock was successfully visualized and analyzed. Lastly, via this process, the historical geography of transhumance in a specific part of Greece was described; foundations were laid for the redetermination of the manner of relocation of transhumant flocks and for the improvement of the traditional routes, where required. The methodology for recording and digitalizing all data can be implemented at any geographical area, aiming at the promotion and preservation of the traditional transhumance practice, keeping its historic and cultural character ever current.

Keywords South-Western Macedonia of Greece · Transhumance · GIS · Geographic visualization · Moving-livestock routes

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Introduction

Transhumance is an animal husbandry system (for goats, sheep and cows), widespread both in Greece and in other countries of Europe and the world (Semple 1922; Evans 1940; Aitken 1945; Matley 1970; Barker 1972). It is a type of extensive stock management, based on outdoor grazing of animals taking advantage of natural pastures. This practice operates seasonally, following herders' decisions to move their livestock and is directly linked with maintaining livelihoods (Giolias 2004). According to Evans (1940), there is a distinction between transhumance and nomadism; although they share similarities, they differ significantly in their cultural settings and social implications. In transhumance, the herd's relocation is seasonal and altitudinal, to and from an established settlement which is regarded as permanent

home (Evans 1940), whilst nomads follow an irregular pattern of movement.

Studies of transhumance generally show that this practice is an adaptation to spatio-temporal variability in climatic conditions; e.g. in most European mountains and in central parts of North America, it is practised by indigenous populations whilst in southern Africa and the Sahel area, it is practised by settlers (Nyssen et al. 2009). Among groups who are dependent on livestock and who employ spatial mobility as a survival strategy, there is an enormous variability in herd management strategies, social organization etc. (Dyson-Hudson and Dyson-Hudson 1980), and thus, there is no uniform relocation model applicable for all groups.

In Mediterranean lands, because of the climate pasturage is of mediocre quality limited in its quantity and seasonal distribution through the year (Semple 1922). Specifically, in lowland areas maximum forage production occurs in the winter-spring period, whilst in mountainous areas summer is the growing season (Ruiz and Ruiz 1986). So, goats, sheep and cattle are moved in spring—usually in May—from their winter pastures (the plain or the lowlands) to mountainous pastures where grazing on natural vegetation is ensured for the summer months. In fall, from the last days of September until mid October, the flocks return to winter pastures (Evans 1940). Essentially, this seasonal movement takes place so as to ensure that the flocks have available food and are protected from seasonal weather conditions. The repetition of these movements led to the development of fixed migration routes.

In France, the ancient network of droving roads or "*drailles*" that snake up from the coast to the summer pastures is testimony to the antiquity of transhumance (Cleary 1988). "*Drailles*" ranged in length from 500 m to 10 km, but were in a very poor state with many ending up abandoned or, more frequently, incorporated into the fields of neighboring farmers (Cleary 1988).

In Italy, the principle transhumant routes ("*tratturi*") and the connecting tracks ("*tratturelli*") appear to be the basic elements of transhumance and played a central role in the history of the Italian peninsula (Meini et al. 2014). Circa 111.5 m wide, they represented a safe and solid pathway and, at the same time, ensured the availability of meadows and pastures during livestock migration. In 1977, with the Presidential Decree n. 616 (Art. 66), routes and tracks passed under the sole authority of the regional governments (Meini et al. 2014).

In Spain, the network comprises different types of droves: royal drove roads, termed "*cañadas reales*," with legal widths of ca. 75 m, and smaller trails, known as "*cordeles*" and "*veredas*," with widths of 37 and 20 m, respectively (Oteros-Rozas et al. 2013). The system was completed with a number of resting places reserved for the sole use of the migrating flocks which competed not only with local agriculture but also with local livestock raising (Ruiz and Ruiz 1986). There is a whole lot of history surrounding the legacy of "*cañadas*" which appear in a Royal Charter of 1284 (Aitken 1945) a fact that shows the importance of these routes in Spain. The Royal Castillian Drovers' Roads could be considered as ample systems of 'elongated pastures' designed to nourish millions of sheep during long migratory journeys (Aitken 1945).

Elsewhere in Europe, in Romania the shepherds migrated along a series of "sheep roads," known as "*drumurile oilor*" or "*drumurile de oi*", which have been in use since the eighteenth century, consisting of a dense network covering most of the territory of present-day Romania (Matley 1970) but which was not officially designated as a transhumance network (Juler 2014). In Scotland, drove roads varied greatly in appearance and formality, from ill-defined hill-tracks to graveled military roads (Lowdon 2014). There is a history of numerous Acts of Parliament that led to many drove routes being enclosed by stone or turf walls, constructions that channeled and constricted the movement of drovers and animals (Haldane 1952).

International literature confirms the historical character of transhumance in other continents as well in Australia, squatters and graziers living in the northern areas of the state quickly developed routes, known as "*Travelling Stock Routes*" (O'Connor 2004). Legislation contributed to the development of the travelling stock routes with widths ranging from 60 to 1600 m according to use at specific times (Cameron and Spooner 2010). In Africa, the "*Transhumance corridors*" are strips of land reserved for livestock passage to access pasture, a source of water or other herd infrastructure (Kitchell et al. 2014). As the management and movement of African livestock were sometimes associated with conflict (Beinart 2007), these corridors were recognized by both farmers and pastoralists as a factor for peace (Salihou 2016; Shittu

et al. 2016). In the United States, the "*livestock driveways*" also exist as an item of Spanish-Mexican heritage, but the legal regime and enforcement about their protection varies widely (Starrs 2016).

With increased vehicular transportation, transhumance routes have lost their original function as long routes for sheep migration (Ruiz and Ruiz 1986). However, the study of mobility systems such as transhumance can improve our understanding of how to increase the resilience of social-ecological systems in the current context of great socioeconomic and ecological uncertainty (Oteros-Rozas et al. 2013). The route and the traditional relocation method of transhumance (on foot) are the main expressions of this mobility and it is very important that they are investigated in the wider framework of transhumance. Recording and mapping the routes, or more generally, recognizing their existence and value in the community will ensure that these roads that form part of our historical memory (Meini et al. 2014) will survive (O'Connor 2004).

This paper deals with the recording and mapping of these particular routes in relation to the geographical space where it evolves. The investigation looks into both the modern as well as the historical dimension of the relocations in a particular geographical area of Greece. The country has a long history of transhumance (Semple 1922; Chang and Tourtellotte 1993); however, there is limited literature on the transhumant routes; for example, there is no record of the exact widths of the paths or of any legal regime for their protection, unlike the case of Spain (Aitken 1945), France (Cleary 1988) or Italy (Meini et al. 2014), where transhumant routes are protected by a special legal framework and an abundance of records have been published.

Given that the traditional transhumance routes evolve in the geographical space twice a year, a geoinformation system (GIS) is used to better depict these routes. This is the tool of choice for examining the historical geography of the transhumance routes in South-Western Macedonian area of Greece for which no cartographic information exists. The original information/data (forming finally a dedicated geodatabase) for the depicting of the traditional routes, are coming from stock managers, who had systematic experience of traditional transhumance. GIS techniques were useful for establishing whether old transhumance routes could serve as infrastructure/resources for the tourism sector (Meini et al. 2014) and for assessing networks of droving routes (Cazorla et al. 2008). It is thus appropriate for recording and storing data concerning the traditional characteristics of Greek transhumance so as provide a future prospect for this traditional practice.

Study area

A large part of South-Western Macedonia was chosen as the study area for this research. This area connects southern Greece with the rest of the Balkans and is where transhumant flocks start their seasonal journey (Fig. 1). Today, this area forms part of the Grevena and Kozani prefectural units, which for a long period of the history of Greece were part of the Grevena and Voio (Anaselitsa) provinces, respectively. They were neighbouring provinces that developed cultural association notwithstanding the diversity within their boundaries. This area saw the formation of societies that played an important role in history and had significant cultural output, whilst at the same time they were associated with advanced stock management (Tsotsos 2011).

The geomorphology of the area is determined to the south-west by the Valia Calda–Vasilitsa–Skourtza part of the Northern Pindos Mountains, by the Voio Mountain to the northwest, by the Siniatsiko Mountain to the northeast, by the Aliakmonas River to the southeast, and the Chasia Mountains to the south. The area within these limits is mostly occupied by the Aliakmonas basin (Fig. 1), but this is primarily a mountainous area, with its lowest elevation at 600 m.

Geologically, the western side of the study area, i.e. the N. Pindos part, consists mainly of sandstone, schist and serpentinites, with limestone also present at locations. This is a forested area, rich in exploitable coniferous forest (mainly black pine), and deciduous trees (beech and oak). From a geological point of view, the northwest side of Voio Mountain is similar to the N. Pindos Mountain, rich in chestnut and beech and black pines at altitudes of more than 1000 m. The basin within the region consists of low and rounded hills of sandy clay and conglomerates, deeply incised by the many small tributaries of the Aliakmonas River. In the 600–1000 m altitude zone, the main type of vegetation is oak woodland. The northeast side of the Siniatsiko

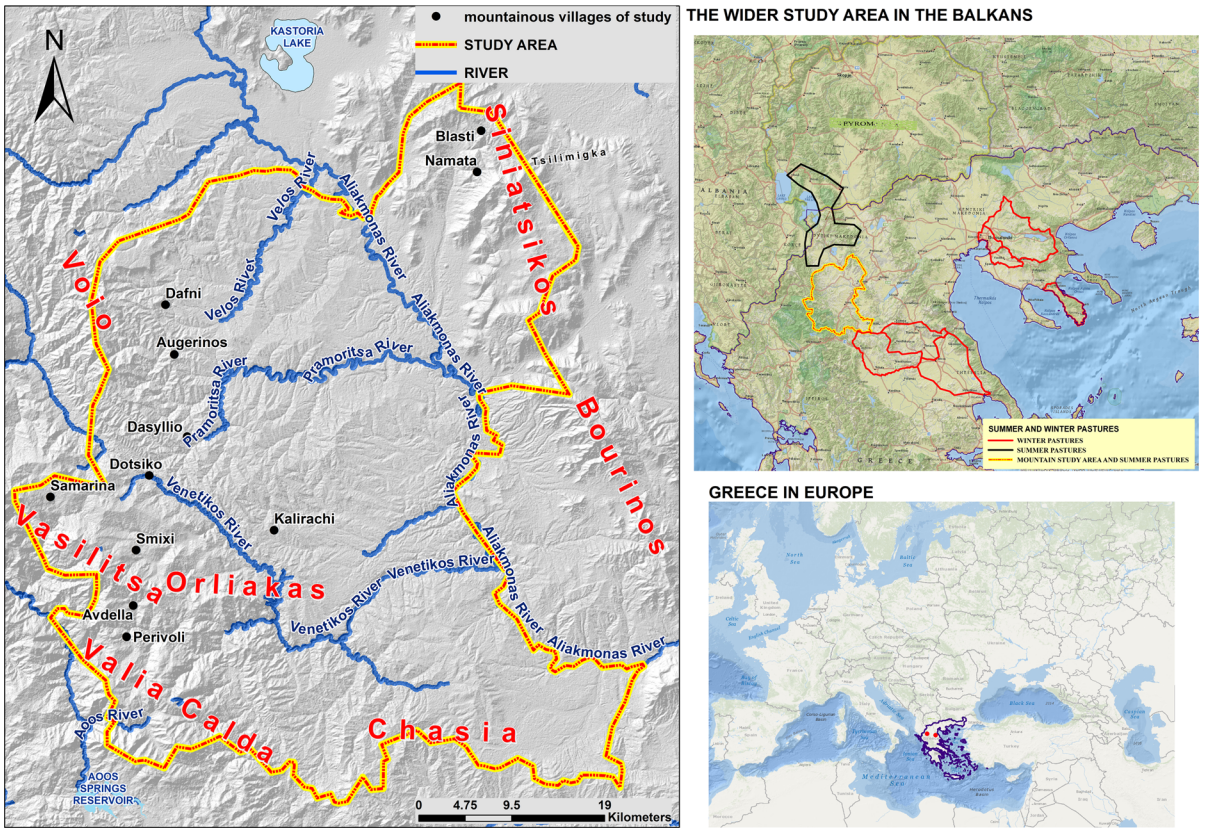

Fig. 1 The settlements of the study and the wider study area

Mountain is characterized by limestone, and relative limited forest cover with extensive bare areas (Tsotsos 2011).

The climate of the area is transitional from Mediterranean to continental, with high rain frequency, cold winters and relatively warm summers. In particular, in basins and valleys, the summers are hot whilst the mountainous areas at above 800 m enjoy cooler summer temperatures. Winters are generally harsh, with more frequent snowfalls in the mountainous areas. The relatively equal distribution of rainfall during the course of the year helps maintain the low grassland vegetation of the higher altitude areas (Tsotsos 2011).

In the Grevena and Anaselitsa study area, the movement of herders, their families and their livestock took place between the mountainous settlements and the winter grazing pastures ('cheimadia') on the Plain of Thessaly (Sivignon 1968; Chang and Tourtellotte 1993) or the lowlands of Central Macedonia. Reference to the transhumance of pastoral families from Pindos, with their livestock, was made by European travellers/researchers in the nineteenth century and the beginning of the 20th (Pouqueville 1995; Wace and Thompson 1989). Certain mountainous villages saw their whole population and their livestock abandoning them during the winter months for lowland areas. More recently, the only residents in winter were the guards of the village. These settlements constitute the starting point of transhumant livestock herders moving towards areas with better winter living conditions—with the latter over the years becoming their permanent residence (Ntassiou 2014). However, when the mountain pastures in the study area were not sufficient for grazing, other summer pastures were used in other regions or administrative districts.

Summary of mountain villages studied

In total, 190 settlements are located in the study area (including deserted settlements); these were distinguished in categories depending on their seasonal

abandonment during the reference period 1881–1940. This time period includes the end of the Ottoman rule (1881–1912) in Southern Macedonia and the transition to the New Greek State, until 1940; and is when transhumance became a characteristic of the area's population.

Depending on how developed livestock raising was, a synoptic separation of the seasonally deserted communities was made so as to identify those for which transhumance and pastoral families' migration would be further examined. The following 4 groups of settlements were considered (listed under their traditional and current names):

1. The four Vlach villages of Grevena (Perivoli, Avdella, Smixi, Samarina) (Wace and Thompson 1989) were characterized by well—developed livestock management (Sivignon 1968; Chang and Tourtellotte 1993), and seasonal desertion by all the population.
2. In the Koupatsarochoria,[1] villages where stock raising is well developed, villages are deserted by a significant proportion of their population in winter, but not by the whole population (Wace and Thompson 1989; Karamanes 2011). These include Doutsko (Dotsiko), Filippaioi, Delino (Prosvoro), Vontetsiko (Polyneri) and Mesolouri. Of these settlements, Dotsiko was examined for the purposes of this study.
3. Settlements such as Kostantsiko (Augerinos), Dramista (Dafni), Mageri (Dasyllio) and Kalirachi, with less developed stock raising, are abandoned by only a percentage of the male population during the winter months (Ntassiou 2014).
4. The settlements Blatsi (Blasti) and Pipilista (Namata) have a significantly developed transhumance practice, despite the mixed economy prevailing in their area (Kalinderis 1982; Papathomas 2012). These two settlements were treated as one as they were neighbouring settlements with such a similar degree of cultural uniformity that they could be treated as an autonomous unit distinctive from the other neighbouring settlements (Ntassiou and Tsotsos 2014).

The selection of these particular settlements (Fig. 1) serves to identify variations in habits, tactics and routes followed during transhumant movements so as to ensure that all different options in the manner of pastoralists' movements and the routes they followed were explored. The settlements examined in this study were also chosen depending on the wealth of information that could be uncovered for each one. From this small geographical area of modern Greece emerges a complicated network that makes up a significant part of the transhumant routes in the country.

The historical and traditional elements of transhumance in Greece

In Greece a *caravan*, or a *falkari*[2] was made up of several families travelling together so as to ensure safety during their journey. Each family accompanied its flocks and followed a particular route for the animal to graze on the available pastures (Ntassiou 2014).

Pastoral family caravans did not deviate from the road networks of their time. At many locations, routes coincided with roads used for other purposes. However, there were significant parts of the route that were used exclusively by the herders and their livestock for their movement from lowland to highland pastures. These sections are still known today as "Vlachostrates" (i.e. routes of the Vlachs). The term does not refer only to Vlachs, but to all transhumant pastoralists. Thus, there are several different routes for the seasonal movement of herders and their livestock from lowland to highland pastures, creating a complex network of routes (Ntassiou 2014).

The places where the falkari set up temporary dwellings to rest or to stay overnight were known as *konakia*. Journey time was thus measured in konakia, i.e. by the number of overnight stays, and not by the distance travelled. The konakia had to be clearings that met the needs of the herders and their livestock in terms of water and grazing (Fig. 2). In other words,

[1] Koupatsarohoria are settlements/villages of Koupatsarides. These population groups of the Grevena area are not distinguished by a specific trait or characteristic, i.e. as Vlachs are characterized by their language (Wace and Thompson 1989). Most researchers agree that the name Koupatsaris comes from the Vlach word 'koupatsiou' which means 'oak tree', and has been used to describe the residents of the oak zone (Karamanes 2011).

[2] *Falkari*: a number of extended stock raising patriarch families along with all their property (animal assets).

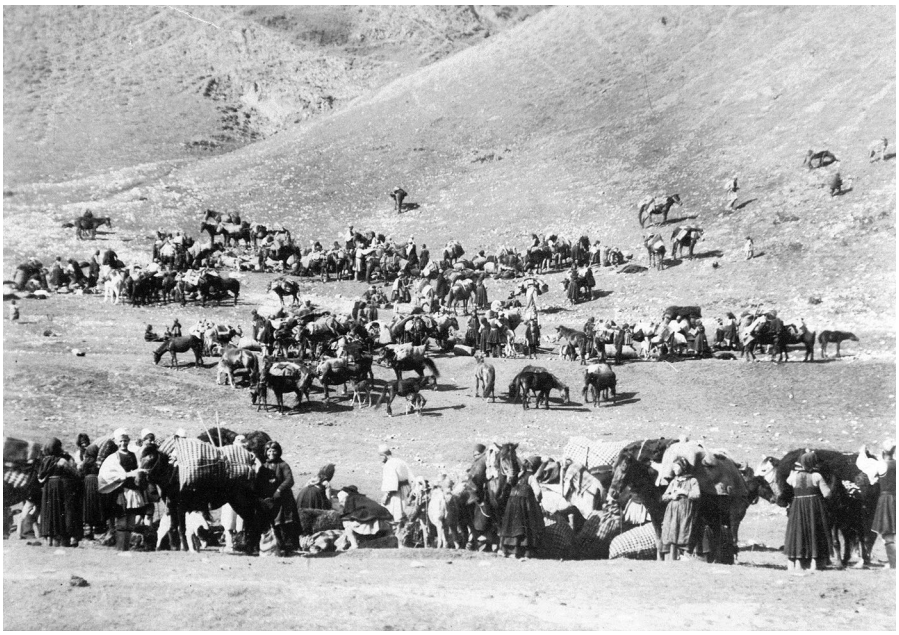

Fig. 2 Congregation of caravania at the konaki (beginning of the twentieth century, Manakia I and Manakia M, *Popescu* 2001*, no Mk-110, Ţuţui* 2011*, 31*)

they had to be near a spring, and away from cultivated plots of land that the flocks could damage. Forest areas were avoided to protect the flock from wild animals. It is worth noting that during the autumn travel to the winter pastures, the herders and their flocks established more konakia and thus, travelled for longer until reaching their destination; in some cases, the journey back to the mountainous pastures was not identical to the itinerary towards the winter pastures, showing differentiations in the route dictated by the different weather conditions or other factors (Ntassiou 2014).

Figure 2 shows the size of the caravans at the beginning of the century. These are caravans originating from the study area that meet at one of the many konakia of the long route. Today, apart from the fact that the practice of the seasonal movement on foot has been diminishing and the flocks are transferred by trucks, certain habits of the relocation itself are also different. Figure 3 shows the caravans collecting at the konaki today; the absence of family is quite apparent in comparison with the Fig. 2. The relocating flock is accompanied by the herder only and the relocation on foot takes place mainly in autumn, with only a few flocks moving on foot in spring. But, the caravans that move on foot along the traditional pre-determined routes stop at the traditional konakia, adhering to the traditional practice. The number of flocks may have changed but not the main character of the transhumant practice.

Fig. 3 At the konaki today (photograph taken by one of the authors)

Methods and data

Data collection for the recording of transhumance routes: interviews

The historical character of this traditional method of movement was approached via first-hand witness accounts provided by stock managers, who had systematic experience of transhumance or continue to experience this traditional form of seasonal movement themselves. A total of 30 interviews were conducted, either with a group or on a one-to-one basis; these were narrative interviews, which started by giving the names of the stopping places (konakia) and the duration of the journey. Interviews were held with herders living in different winter pastures, so that the different routes from the various highland pastures could be recorded (Table 1). The interviews revealed that there were a number of different routes to the same winter pasture and that in some cases, the prevailing one was not the safest or the shortest.

Interviews were in different age groups, as even the younger residents had experienced the seasonal movement. However, particular emphasis was given to the accounts of people born before 1950. In particular, those born from 1919 to 1950 had clear memories of the traditional practice of transhumance between the highland and the winter pastures and had lived through many changes. At the same time, they conveyed the memories passed on by their ancestors, as these have been preserved by oral tradition. A total of 27 different routes were recorded via this process.

Creation of a geo-information system: cartographic and geographic background

The examination of transhumance from a geographical point of view is made possible with the use of GIS, which allows collection, management, storage, processing, analysis and visualization of spatial data in a digital environment (Burrough 1986; Aronoff 1989; Star and Estes 1990). Data consist mainly of spatial and descriptive information. The spatial information concerns mainly the cartographic background of the GIS and locations of objects and attributes in space including the routes. In the case of transhumance, descriptive information comes from oral accounts and narratives, and concerns descriptive characteristics of the objects, irrespective of their position in the space. This information acquires geographical meaning in an appropriate system of geographical coordinates and digital mapping.

For the cartographic depiction of the routes and the wider area where seasonal movements were taking place, a dedicated GIS (based on Esri® ArcGis™ software) was created to record and study the

Table 1 Number of interviews in each settlements based on the age of the interviewees and the corresponding lowland destinations (winter pastures)

Mountainous settlement	Age of interviewees			Winter pasture (administrative district)	No. of routes
	Born 1919–1929	Born 1930–1949	Born after 1950		
Perivoli	3	2	1	Thessalia (Volos, Tyrnavos)	4
Samarina	1	2	2	Thessalia (Kalampaka, Tyrnavos etc.)	2
Smixi			1	Thessalia (Tyrnavos)	1
Avdella			1	Thessalia (Tyrnavos)	2
Dotsiko		4		Thessalia (Gonnoi, Elassona, Larissa)	3
Dasyllio		1		Central Macedonia (Chalkidiki)	2
Augerinos		1		Thessalia (Tyrnavos)	1
Dafni	1			Thessalia (Elassona, Trikala)—Central Macedonia (Chalkidiki)	3
Kalirachi	1			Central Macedonia (Chalkidiki)	1
Namata–Blasti	1	4	4	Thessalia (Volos, Tyrnavos)	8
				Central Macedonia (area around Lake of Volvi)	

residential and transportation system of South-Western Macedonia.

The cartographic background consists of maps that refer to three distinct time periods. They depict part of Central Macedonia, Western Macedonia, parts of Thessaly and Epirus, and enable investigation of not only transhumance, but also geomorphological features and other structures.

The maps are as follows:

- 6 Maps at a 1:200,000 scale and 2 maps at a 1:75,000 scale, author unknown, issued during 1909–1914, although some are dated 1896–1906.
- 61 Maps at a 1:50,000 scale, of the US Army Map Service dated 1953–1955. Produced on the basis of aerial photographs from 1945.
- 61 Maps at a 1:50,000 scale, of the Hellenic Military Geographical Service (HMGS); these are more recent, dated from the 1970's.

In order to depict the geomorphology of the area, a Digital Terrain Model (DTM) was created. A raster-type DTM was obtained from the NASA ASTER GDEM webpage; the DTM representing the Greek terrain was extracted, and was used to create a colour-shade relief coverage that provides a 3-D view of the area, as well as maps of slope and elevation. Furthermore, a shape file was used to depict land uses in Greece during the period 1999–2000, accessible via the open database (http://geodata.gov.gr). It was decided to use data from this period as representative of the modern period and as land use has not varied significantly since the 70's. In addition, the open access Forest Maps of National Cadastre and Mapping Agency S.A. (which are used for the delineation and recording of forests in Greece) were used for acquisition of cover land data for the period before World War II (https://gis.ktimanet.gr/wms/forestsuspension/default.aspx). We used the polygon data based on interpretation of aerial photos from 1945 to describe the land cover type (forests, croplands and pastures); compared with the period 1999–2000 land use data will give the changes of the land cover along the transhumance routes.

Recording and onsite verification of the routes

The interviews described the routes based on the stops (konakia) herders made and the settlements they passed. Villages between these help trace the route, even if the caravan travelled at a significant distance from them and not necessarily through them.

For each group of settlements, a record was made of all routes to the different winter pastures, and their changes over time. Common routes (without significant deviations) were recorded once. All the main axes of seasonal movements and the respective names of the overnight stops (konakia) were therefore recorded. The journey time was measured in konakia. For groups with advanced herding practices, a record was made of multiple routes to all winter pasture destinations used during recent times. Groups 1 and 2 are consistent as regards their winter pasture destinations. Thessaly constitutes almost the exclusive destination for the winter and this paper records only the journeys towards the winter pastures of Thessaly. A characteristic of the settlements of the third group is that the families did not travel with their livestock, nor did they spend the winter always in the same manner. The fourth group initially showed variation in winter pasture destinations that later became more stable. The population of the fourth group were split between the winter pastures of Central Macedonia, and in particular the settlements of Volvi Lake, and the winter pastures of Thessaly and in particular the Tyrnavos and Volos areas.

According to the interviews, livestock were herded along routes that remained unchanged until the introduction of trucks in 1950, which affected migration habits significantly.

Also, with the purpose of documenting the routes, one of the authors followed 5 flocks of goats and sheep (numbering more than 500 animals per flock) during their autumn journey to the winter pastures, in October 2011, 2013 and 2015. The journeys were from the mountainous study area towards Thessaly. The route and the temporary stops (konakia) were recorded with the use of Global Positioning System (GPS) and in particular, a GARMIN^{TM} series eTrex GPS to define coordinates. It is worth noting that at certain sections of the routes, different flocks from different settlements of the study area were moving at the same time (keeping however a distance between them). In particular, in 2015, along a particular section of the route from Western Macedonia to Thessaly, six different flocks were travelling during the same day (three from Samarina, one from Perivoli, one from Avdella and one from Smixi). The smallest of these comprised of 800 goats and sheep whilst the largest

comprised more than 2000 goats and sheep. In total, more than 6000 goats and sheep were travelling on the particular transhumant route. This picture gives an indication of the current situation as regards the relocation using the traditional method of the transhumance originating from the study area.

Digitizing routes, konakia and land cover types

Visualization of the output resulting from route records has been made possible by having them plotted on a suitable map background. The maps primarily used as backdrop were those published by the US Army in the 1950s. These were combined to create a 61-map conglomerate. They contain detailed information on the road network in the specific period of interest (1945 aerial photos), and from earlier periods. They illustrate paths not described in other map series. Moreover, they provide detailed place names which, in several cases, match the listed locations of overnight stops (konakia). Where the place name of an interview is not identified, then a map from another series is used to identify it.

The rendition of herd routes on maps was developed by plotting:

1. point objects that correspond to the konakia layer and
2. linear items that correspond to the transhumance routes layer.

At first, the konakia were approximately plotted and then, the routes were traced. The konakia were identified according to the place name indicated in the interview, or the description of the geographic site in relation to a nearby community or certain landmark. After placing the point symbols at the respective positions, each route was traced and plotted on the map background. It is interesting to note that there are differentiation between the routes taken during the spring migration to the highland pastures and the fall return to the winter pastures, as the weather conditions of each season affected the decision as to which road would be taken and how the herd would move.

In total, approximately 4000 km of herd routs were digitized, of which 1700 km lead to the wintering regions of Central Macedonia and the summer pastures of Florina, Kastoria and Pelagonia; and 2300 km that lead to the respective regions of Thessaly. In addition, 162 fixed positions that were traditionally utilized as overnight stops or rest points (konakia) were mapped. These objects, combined with miscellaneous data of the geographic space, demonstrate the scale of transhumance undertaken spatial and temporal terms.

Finally, the forest map extracts covering the transhumance route alignments were inserted as pictures in ArcMap environment and geo-referenced using the affine polynomial (1st order). The land cover type of forests, croplands and pastures were plotted as polygon features on the resulting basemap. It is noted that only the polygons across the routes were plotted because only the intersected area (between the polygons and the route alignments) was needed.

Results

Cartographic depiction of transhumance routes

Transhumant routes from the mountain settlements to winter pastures were plotted, describing the geographical space of transhumance. Generally, this is a network of seasonally moving herders in South-Western Macedonia (Figs. 4, 5, 6), connecting Western Macedonia to Central Macedonia and Thessaly. It has been created by herders, although it was not used only by their families and flocks, since it followed the alignments of road networks available during each era. The key points of the network are the mountain settlements, the winter pastures and the konakia. The routes taken by transhumant herders to the winter pastures are shown in Fig. 4 for the winter pasture of Thessaly, Fig. 5 for those in Florina, Kastoria, Pelagonia and the Fig. 6 for the winter pastures in Central Macedonia. The key points in these maps are the settlements at key geographic positions, and landmarks along the designated routes.

Some additional features that characterize the routes making up the transhumance network, can be identified. First, each main route gave rise to local deviations, according to the historic conditions and situations; where sites suitable for grazing existed, flocks would divert from the main route to create an alternative route. Secondly, the routes traversed settlements/villages as well as major urban centres, as they generally remained on the alignment of arterial roads that flocks and caravans used to follow. Thirdly, the routes crossed areas of different types of

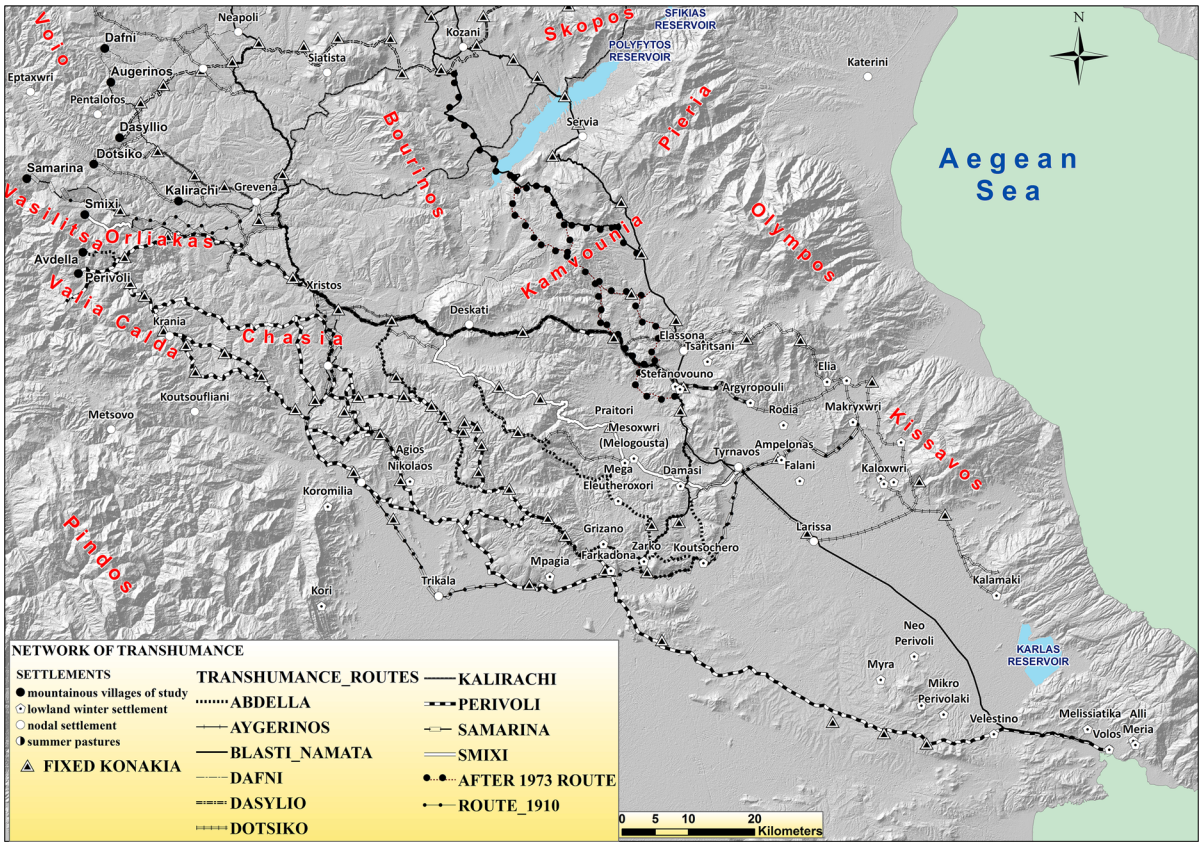

Fig. 4 The network of routes leading to winter pastures in Thessaly (on hillshade, 1:450,000 scale). On the map, diversification of the routes to the Polyfytos-reservoir is visible, after the reservoir's creation in 1973

geomorphology, as the mountainous terrain alternated with semi-mountainous terrains and lowlands. In the mountains areas, because of the steep inclination, the routes followed a helical shape, whilst in the semi-mountainous areas there were fewer deviations as slopes were gentler. Out in the lowlands, the routes became straight lines. Fourthly, in the plains and the wetlands, journey times were shorter. This is because the herders had to ensure that no damage was done to cultivated areas and also, to avoid spending more time than absolutely necessary in these dangerous climate conditions created by the wetlands (swamps). Finally, rivers had to be crossed. Where no bridge was available, livestock was transferred using "perataria".[3] Where neither bridges nor perataria were available, and the river was inaccessible due to bad weather conditions, the stay at a konaki was extended until crossing became possible. To cross the river, the herders chose locations of lower slope and wide riverbeds. There, the waters ran more slowly and the riverbeds were shallow, and river crossing was facilitated.

Characteristics of the routes

The routes of the study area do not have a set width. Also, their lengths differ depending on the distance between the summer and the winter pasture. As stated above, only the primary segments were recorded for the different destinations (winter or summer pastures). Table 2 presents indicatively the distances between certain key point settlements from where routes branched out (shown in Figs. 4, 5, 6). The primary segments from our study area to the winter pastures of Thessaly or Central Macedonia are noted against the primary segments of the routes. Summing up the individual segments, depending on the route we want

[3] *Perataria*: a ferry, platform or raft that takes people and cargo from one side of the river to the other.

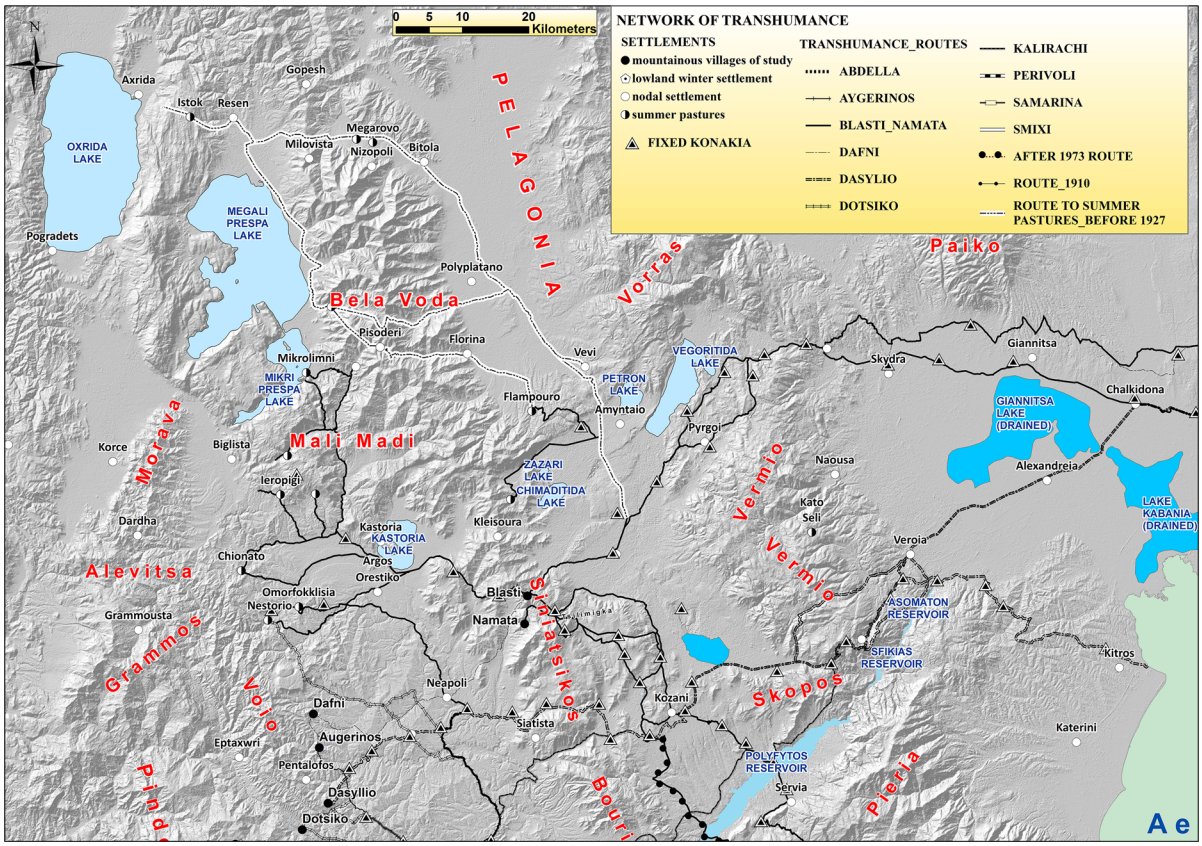

Fig. 5 The network of routes leading to summer grazing sites in West Macedonia (on hillshade, 1:450,000 scale). The flocks of Western Macedonia reached the pastures of (current) FYROM, even after borders were established in 1912. After 1927, the Serbian state banned the free movement of Greek flocks within its borders

to determine, shows the total distance covered by the flocks in their seasonal relocation.

The end points of the routes (winter and summer pastures) determine the total length of a transhumant route. One of the most extended route that joins the western mountain area with a winter pasture at the eastern end of Halkidiki, Central Macedonia (such as Sykia) is approximately 400 km. Similarly, the route that joins the western mountain area with a winter pasture at the southern end of Thessaly (such as Volos) is approximately 250 km. As regards the distances between the konakia, they range from 7 to 20 km. Daily, the transhumant flock covers a distance of 10 km in average. The larger distances of 20 km are covered in certain cases only, when certain segments of the route require accelerated movement.

The route alignments are characteristic not only of the fairly long overall length of the journey that the transhumant flock covers in its seasonal relocation, but also of the great variances in the elevation. Mountainous settlements are located at altitude of more than 1000 m whilst the winter pastures can be found even at 20 m; the elevation profile of each route shows the itinerary that the flock follows at a vertical section of the terrain. As also noted above, the fourth group shows dispersion in the geographical space as the herders moved both towards the south (Thessaly area) and the east (Central Macedonia area). The elevation profiles of the two routes that start from the same settlement and end at opposite directions provide another way of depicting the changes caused by mobility in the geographical space (Fig. 7).

Changes in the transhumance routes over the years

The long lasting Turkish occupation of Greece (1453–1912) established the conditions for extended movements outside the current borders of Greece. The

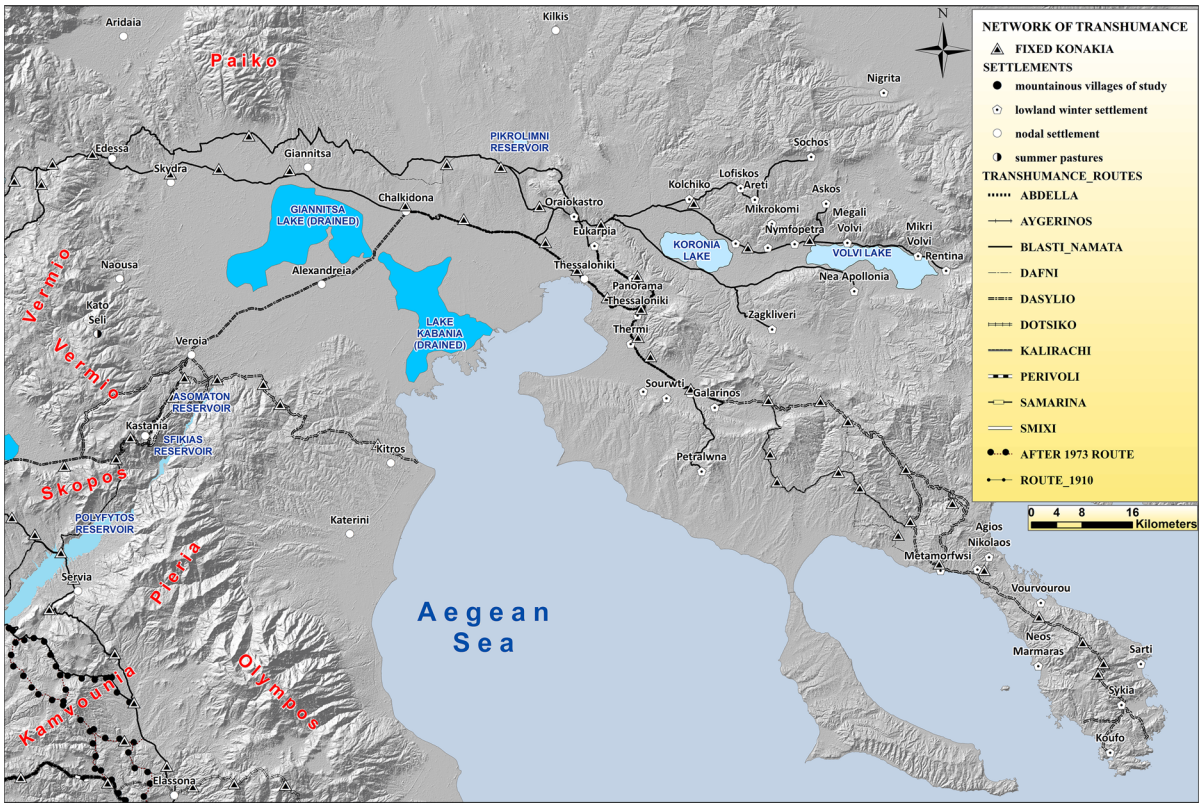

Fig. 6 The network of routes leading to overwintering sites in Central Macedonia (on hillshade, 1:450,000 scale). On the map, the swamp of Giannitsa territory which—reasonably-added difficulties to the flocks' journey is noticeable. After 1934, the drainage of the Giannitsa lake resulted into the development of cropland properties

study area was liberated in 1912 whilst the southern part of Greece was liberated earlier (in 1834), followed by the successive annexation of areas such as Thessaly in 1881 (Fig. 8). The amendments in the borders caused amendments in the alignment of the routes. Many routes and secondary or alternative alignment were used after the liberation of Macedonia from the Turkish occupation in 1912, as crossing the border between Turkish and Greek territory after the annexation of Thessaly in 1881 was not possible at any point across the border. After 1912, parts of routes changed and herders were somewhat more able to follow alternative routes. Thus, the network followed by the herders and their livestock developed numerous branches, particularly in Thessaly (Figs. 4, 8).

The routes presented in this paper belong to the network of transhumance routes that was being developed until 1940. After the Second World War, the conditions changed again. With the introduction and gradual increase in car use, livestock was moved along central roads and across bridges at night time. Also, in many cases, transportation by train served certain parts of the routes, and after 1970, use of trucks transformed seasonal transportation. Some of the routes presented herein are no longer being used for this reason, although they could potentially be put to use again.

After the 1950's, systematic land cultivation began turning uncultivated or fallow fields into productive plots of land, affecting the seasonal transportation of flocks. Most routes now run through private land; combined with the fact that there was never legal protection for the routes of vlachs, this has led to the gradual elimination of certain routes. Seasonal transportation of herds to mountainous areas in the spring became difficult as cultivation expanded and necessitated that routes were modified to prevent damage. Thus, gradually, the spring relocation was abolished, with the autumn relocation becoming the prevailing one.

Table 2 Lengths of the routes segments between key points

Primary/secondary segments	Key points (nodal settlements)	Length (in km)
To Thessaly		
Primary segments	Grevena–(Deskati)–Elassona	95.00
	Grevena–(Trikala)–Farkadona	112.00
	Kozani–(Servia)–Elassona	76.20
	Grevena–Kozani	40.00
Secondary segments	Farkadona–Volos	90.00
	Elassona–Tyrnavos	25.00
	Tyrnavos–Volos	60.00
	West mountain area (Samarina, Smixi, Avdella, Dotsiko, Dasyllio, Kalirachi, Dafni, Augerinos)–Grevena	40.00–60.00
To Central Macedonia		
Primary segments	Veroia–Oraiokastro (Thessaloniki area)	75.00
	Edessa–Oraiokastro (Thessaloniki area)	100.00
	Oraiokastro (Thessaloniki area)–Sykia	165.00
	Oraiokastro (Thessaloniki area)–Rentina	140.00
	Kozani–Veroia	60.00
Secondary segments	Blasti–Edessa	90.00
	Blasti–Kozani	35.00
	Tsotyli–Kozani	60.00
	West mountain area (Dotsiko, Dasyllio, Kalirachi, Dafni, Augerinos)–Tsotyli	20.00–30.00

The investigation of the routes in the geographic and the geophysical space

In a GIS environment, it is possible to process various aspects of the transhumance. Spatial analysis tools allow representation of connections between the routes and various characteristics of the geographic and the geophysical space where they take place. These characteristics are associated with the historical and functional character of the established routes. Part of this functionality rests on ensuring quality grazing for the flock during the journey, utilizing the available natural vegetation. In a GIS environment it is possible to investigate differentiations in route alignments due to changes in the natural environment (such as construction or other types of technical work, such as reservoirs, dried-out wetlands, motorway construction) and changes in land use.

The spatial data that interact with the transhumance routes (or network) are: the primary asphalt roads and the polygons representing land cover (pasture, cropland and forest). Pastures indicate grazing area during the journey, croplands indicate zones of conflicts between transhumant herders and farmers whilst forestland is not suitable as a resting place (konaki) but provides grazing area especially for the goats. These are the critical points that influence the herders' choice of a transhumant route.

Specifically, the intersection analysis of both the route alignments and the konakia with the land cover polygons gives the percentage of route lengths and the number of konakia that fall into each type of polygon. It is important to use the intersection analysis tool because the attribute values of the input feature classes are copied to the output feature class, and thus the intersected route segments are characterized with the corresponding land cover type value. Likewise, the intersection between the route alignments and buffer zones of the modern main roads give the percentage of route length that coincides with the modern road network.

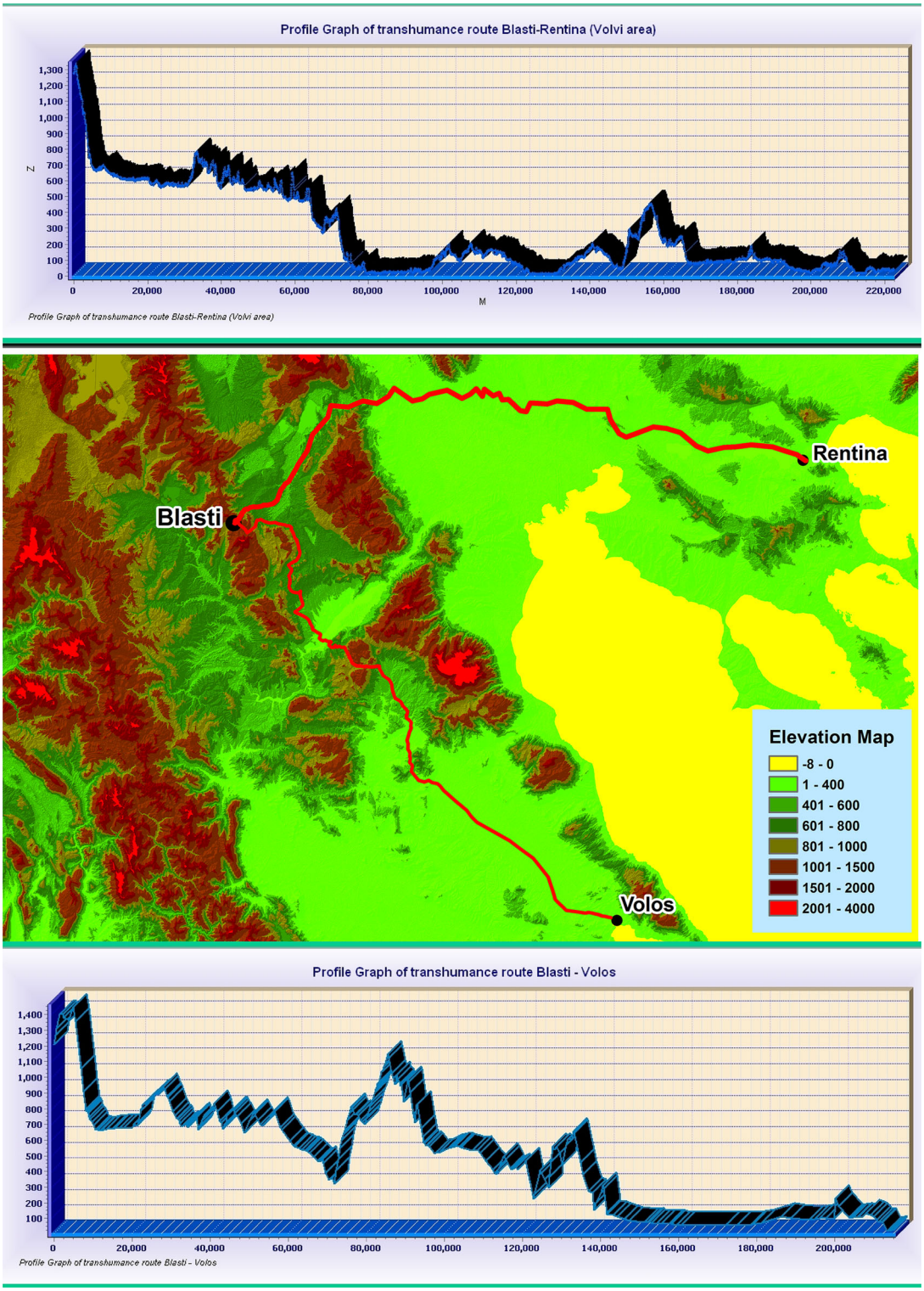

Fig. 7 The example of the transhumance routes from Blasti towards Thessaly and Central Macedonia. The elevation profiles show variances in the 2 different destinations along 200 km

Detection of uneven or "difficult" locations

The slope maps produced provide identification of locations of steep relief that the herders tried to avoid, either by adopting a switchback route, or by paving steep paths with steps. It is therefore possible to identify the "difficult locations" of each route, several of which were also reported as such during the interviews. Steep slopes (above 60%), rivers and lakes can be mapped to assist modern herders in organizing their journey. Alternative route alignments can be developed that may be longer and easier. However it is worth noting that steep slopes do not make the route more difficult for the livestock but only for those accompanying the animals. Steep slopes are found mainly in Mountainous areas (elev. $>$ 800 m) and at the points of change from semi-mountainous zone (elev.: 600–800 m) to Lowland zone (elev. $<$ 600 m), or to mountainous zone. From the statistical geometrical data of the steep slopes of the routes, it is concluded that the intense inclination may continue for 1 km at most. Table 3 presents the lengths of the sections of the route with steep inclination (above 60%) in each administrative district and the percentage of steep relief identified in each elevation zone per district. It is worth noting that steep inclinations are identified at the lowlands of Thessaly, whilst in West Macedonia (where the mountainous study area is found) formed mainly by mountains, there is high percentage of steep relief.

Investigation of the changes along the routes

After 1950, cars were introduced in Greece making it more difficult to transport livestock on main roads if these coincided with the transhumant routes. Using GIS tools, the sections of the routes that coincide with main roads can be marked so that in these locations, an investigation can be made into modifying the route to facilitate the journey of flocks and keep them away

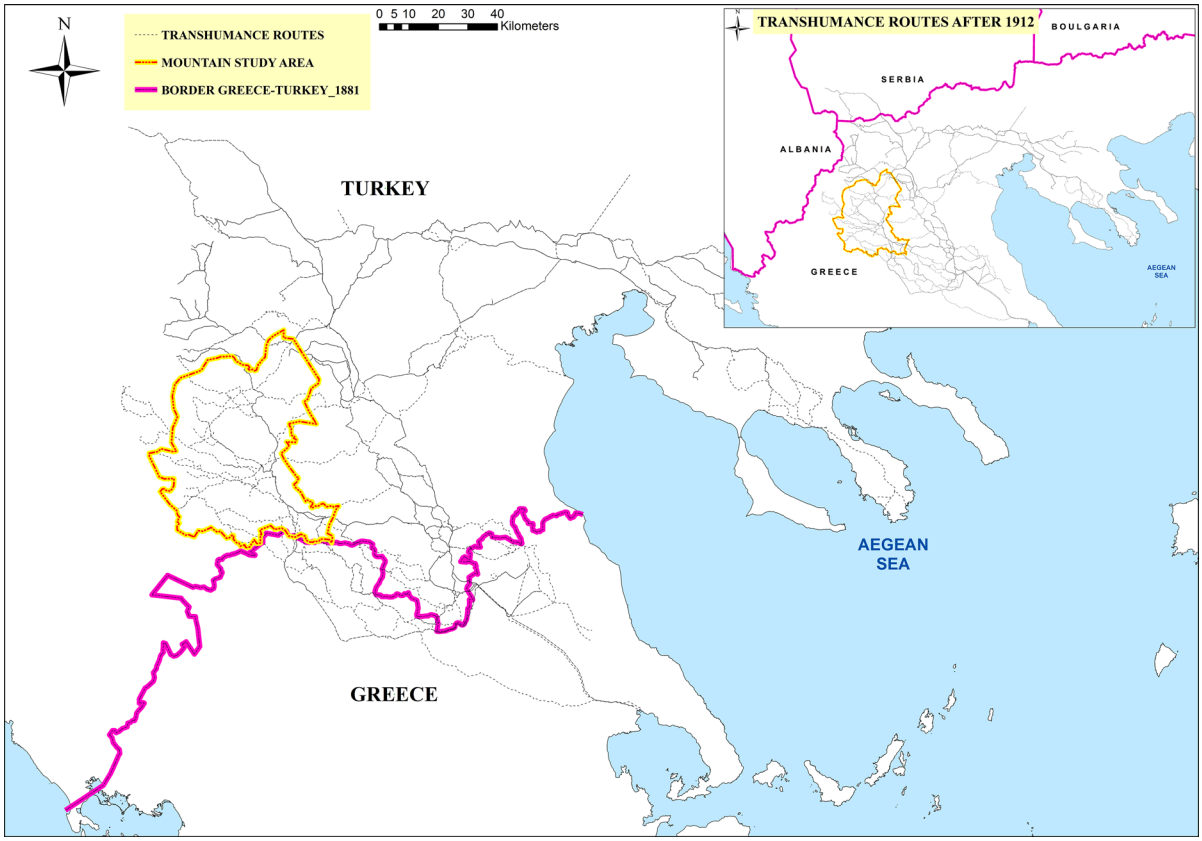

Fig. 8 The mountain study area was under Ottoman occupation until 1912 and the border Greece–Turkey, which was established in 1881, was an obstacle for the transhumance network

Table 3 Total lengths of the steep sections of the transhumance routes (slope > 60%) and percentages of the steep points

Administrative district	Total length (in km)	Percentages of the count of the steep points in the three elevation zones		
		Mountainous (%)	Semi-mountainous (%)	Lowland (%)
Thessally	6	20	20	60
Central Macedonia	3	25	30	55
West Macedonia	17	78	20	2

from cars (Table 4). Optimizing the alignment of traditional routes on the basis of current data is pivotal for maintaining transhumance for the future generations.

Routes also frequently run through forested areas and pasture that encourage foraging and facilitate the herd's journey. Croplands on the other hand require the attention of the herders in order for the flocks not to damage crops. The diagrams show the percentage of the sections of the routes that are intersected with these three types of land cover (Fig. 9); forests and pastures have a positive effect on the herd's relocation whilst the croplands have a negative impact.

The investigation of parts of transhumance routes that coincide with main roads or run through areas with different vegetation cover was made on the basis of their particular distribution in Western Macedonia, Central Macedonia and Thessaly. Each region presents different characteristics as regards geomorphology and historical development, and it is therefore important to investigate the transhumance route network on the basis of these distributions. A traditional form of transhumance takes place towards Thessaly, whilst in Central Macedonia, movements mainly use trucks.

Spatial analysis of the transhumance routes in relation to the modern road network show the high kilometric percentage of transhumance routes in the Central Macedonia region that coincide with the main modern road axes (Table 4). Equally high is the percentage of transhumance routes that run through agricultural land in the same region (Fig. 9). Both these high percentages explain up to a degree the reason why the traditional method of relocation of livestock towards the winter pastures of Central Macedonia has been abandoned, as traffic in combination with cultivation significantly obstruct livestock movements.

Interpretation of aerial photos from 1945 enabled classification of the land use in each region. Even if certain land was characterized as agricultural before the Second World War these were not cultivated systematically (land fallowing). The percentage of route length running through agricultural areas in 1945 was in fact lower than that deduced from spatial analysis, thus the risk of damage to crops was significantly lower than at later dates.

Comparing the percentages of the length of the transhumance routes that ran through agricultural land in 1945–2000 shows a significant increase in arable land. Over the years, land clearing of forest has reduced the percentage of forests along the length of the transhumant routes, whilst the percentage of the respective grassland areas was always relatively limited (Fig. 9).

Table 4 Lengths and percentages of the sections of the routes in three different administrative districts that run though primary road axes

Administrative district	Total length (in km)	Length running through primary roads (in km)	Percent on the modern primary roads (%)
Thessaly	1,156,818	208,219	18.00
West Macedonia	1,492,695	424,964	28.47
Central Macedonia	836,356	554,498	66.30

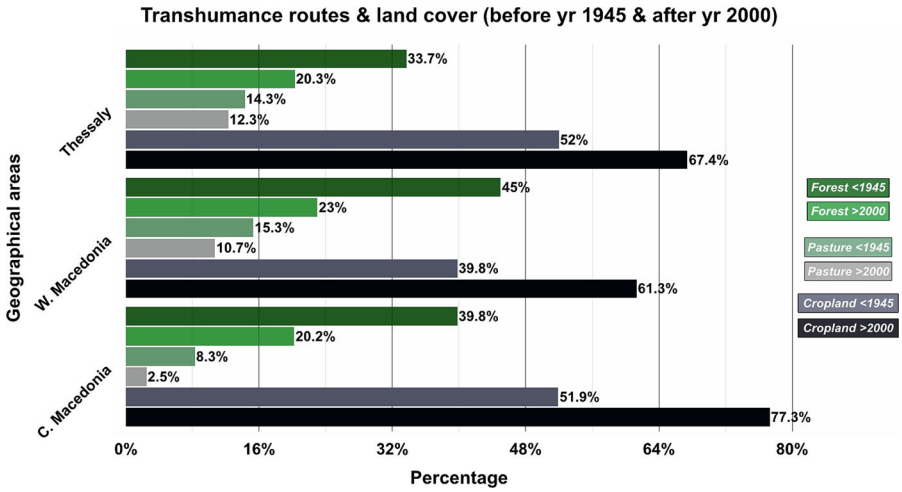

Fig. 9 Diagram of the percentages of the sections of the routes in three different administrative districts that run though forests, pastures and croplands (cover_land_2000 and cover_land_1945, respectively)

Generally, the increased percentages in cultivated lands along the traditional routes (and their overlapping with the main roads) show the need for parts of these routes to be changed. High percentages of forest and grasslands indicate the suitability of the traditional alignments for the movement of flocks. In Thessaly and Western Macedonia, changes in land cover across the routes are not so extensive and as a result, the traditional routes are still followed by some flocks.

Data on land use enable conclusions to be reached regarding the traditional konakia that fulfilled certain conditions. Today, several of these areas (agricultural land and forest land (Fig. 10) have specifications that suggest that they are unsuitable locations for overnight stops. The change in the use of land is unavoidable over the passage of time with reforestation/clearing operations affecting the areas' vegetation cover (Fig. 10). Thus, konakia today are relocated some kilometres or metres away from their traditional locations. During the autumn journey however, neither the agricultural nor the forest areas are prohibitive for a konaki as natural vegetation is limited and most crops have been harvested.

Web-GIS opportunities

The digitized network of herders and their flocks (reconstructed from the route alignments), the konakia, the highland grazing areas and the winter pastures form the database of the transhumance process. This database dynamically illustrates the historical network of transhumant families and livestock in southwestern Macedonia, which is recorded here for the first time in Greece. These data have now been stored for the use of future generations of stockbreeders that will practice transhumance. Their file format means that that they can be available via web applications that do not require specialized equipment or GIS software.

Cartographic depiction of routes in a web environment such as an online GIS platform, accessible to all potential stakeholders, will provide a valuable resource for conservation and development. To this effect, some data were uploaded on an Esri® ArcGis-Online trial where they constituted several thematic layers. The produced shape-files were input in the ArcGis-Online environment. Each route can be investigated separately; a Mapping Application such as an elevation map or a story map describes its geometric and historical characteristics whilst an elevation map may give the variations in elevation along the route. The transhumant herder can use these apps to plan their journey or to view their position in real time. Tourists can also use the apps of ArcGis-Online to view the routes, visit them and experience this traditional journey themselves.

Discussion

This research led to the recording and mapping of the transhumance routes within a part of Greece that has a great tradition in transhumance, for the first time even in Greece. Accounts by herders that were interviewed

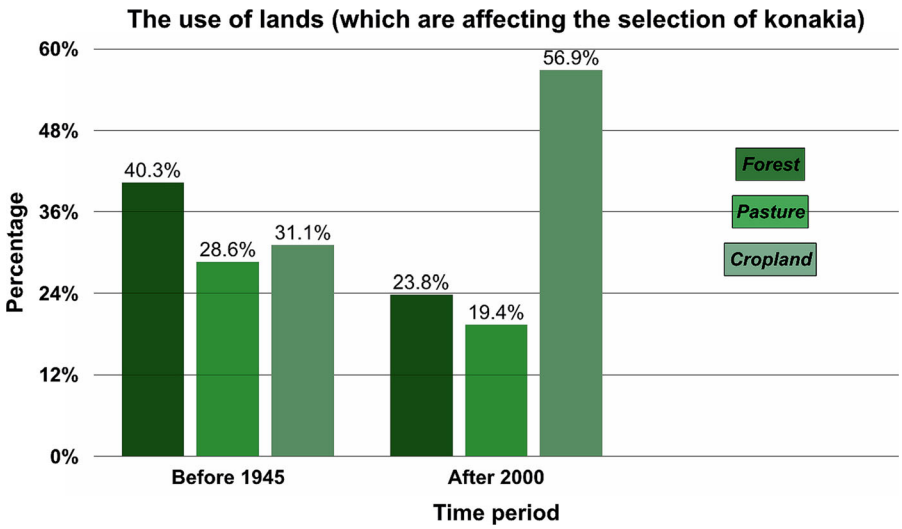

Fig. 10 Distribution of konakia and the use of lands affecting their selection (cover_land_2000 and cover_land_1945, respectively)

for the purposes of the study revealed the historical routes which were found not to deviate significantly from the modern ones. The number of interviews was sufficient so as to cover the different routes and to provide a reliable source of primary data. Use of GIS tools facilitated the identification of the characteristics of the routes and the data provided during the interviews leading to their detailed cartographic depiction.

The mapping of this network of transhumant routes sets the base for the promotion and preservation of parts of the traditional 'Vlachostrata', the herding routes of Greece, and establishes its eligibility for inclusion in the wider network of historical routes, such as the Via Egnatia, the Silk Road, and other roads of similar historical importance. Provided that the State mechanism shall support such an initiative, their delineation, fencing and protection via a legal regime is possible, as in Spain (Aitkens 1945; Ruiz and Ruiz 1986), France (Cleary) and Italy (Meini et al. 2014), countries that have also rich tradition in transhumance. Also, with the historical character of these routes documented, conditions are established for their touristic exploitation by appropriate bodies and agencies.

Conservation of transhumance routes contributes to the conservation of biodiversity and ecological processes (Baena and Casas 2010), thus the continuation of transhumance must not be sought for historical reasons only. But in Greece, transhumance has been in decline already since the early 1980, similarly to other countries of the Mediterranean (Ruiz and Ruiz 1986; Cleary 1988; Meini et al. 2014) and the relocation on foot has been limited. Today, due to the economic crisis in Greece, a percentage of the herders of the study area have turned to the traditional transhumance practice (relocating their flocks on foot). Without any official records being available, it is reported that approximately 20 flocks (of 1000 goats and sheep on average) are moving on foot from the settlements of the study area to Thessaly. As explained above, the traditional relocation to Central Macedonia has become practically impossible. The delineating and fencing of the routes to Thessaly and Central Macedonia can change the picture and mark a shift in perspectives, with the traditional transhumance practices revived without being viewed as an inconvenience to the herders. In order for the flocks to move on foot, it is important for segments of the route that run though the primary road network or properties to be realigned. This way, flocks will not obstruct road traffic or give rise to disputes with property owners. In many cases, delineated zones settle land use conflicts among farmers and transhumant herders (Shittu et al. 2016) and their width allows flock grazing during the transfer (Ruiz and Ruiz 1986; Lowdon 2014; Landi and Calzolai 2015). The same applies for locations where the konakia are established; these can also be marked and protected to ensure the convenient resting of the flocks and herders. The diagrams showing the percentages of routes that run though three different administrative districts help identify the problem areas

(overlapping with roads, crossing properties) per district, providing the base for action by the competent State authority.

As concluded, the routes to Thessaly extend to 150–250 km in average whilst the respective routes to Central Macedonia are 200–300 km. In the Romanian region of Transylvania, treks between summer and winter pastures can cover distances of up to 300 km in one direction (Juler 2014). In Spain, the whole of their network extends over more than 125,000 km and occupies 422,000 ha, or 0.83% of the country (Cazorla et al. 2008) with the drove road between Montes Universales (in Teruel) and the southeastern Sierra Morena (the southern fields of La-Mancha) for example being approximately 410 km long. The lengths of the routes depend on their end-points, however, as seen above, they are comparable for most countries. On the other hand, width shows the available room for flocks, and thus, it is important that they are set out when no legal regime exists (as in the case of Greece). The delineation and characterization of the transhumant routes requires that the countries cooperate to adopt uniform standards. The establishment of a wider network that covers many countries with a tradition in transhumance may help restore this practice. A network on transhumance is helped by the increasing digitization of historical data (Landi and Calzolai 2015) and this paper contributes to this effort to promote this cultural expression.

As regards its technical characteristics, the Greek transhumance route network presents many similarities with the respective networks of other countries. One basic characteristic is that it is constituted by some major transhumance routes which are linked with a complex system of minor routes (Ruiz and Ruiz 1986; Landi and Calzolai 2015). In Spain the system was completed with a number of resting places reserved for the sole use of the migrating flocks (Ruiz and Ruiz 1986). In Greece these resting places are the "konakia" and constitute a basic element of both the network and the traditional transhumance practice. In this paper, the "konakia" are depicted with great accuracy in the geographical space, whilst in the literature on transhumance routes in other countries that is referenced herein, the respective resting places have not been described in such detail. The Greek network of transhumance is part of the historic geography of Greece; at the same time, it provides the basis on which this practice can be revived both as a livestock management system and for cultural and tourist purposes.

Conclusions

This research contributes to the documentation, analysis and promotion of the traditional transhumant routes, thus assisting in preserving an important element of cultural heritage, and makes important information available to younger livestock herders. With the help of the appropriate historic cartographic material, oral tradition data were organized and stored in the respective geodatabase, being made available to future generations for research into transhumance practices. Use of a geodatabase depicts in a documented manner the historical network constituted by the transhumant routes of the herders of South-Western Macedonia, travelling along with their livestock and families. The dynamic character of the geodatabase provides potential for regular updating, allowing the research to be extended as regards as spatio-temporal framework. Thus, by adding data for other geographical areas or time periods, the network may be extended, representing the extent of the seasonal migration of people and their livestock in a wider region where transhumance exists.

Supplementary material

Some of the applications for this paper (in ArcGis-Online environment) are available online. The network of the transhumance routes and the station places (konakia) are available at http://arcg.is/vabT5, an example of elevation map at http://arcg.is/2oTuE1K and, finally, an example of a story map at http://arcg.is/2oZfVCN.

Compliance with ethical standards

Conflict of interest Both authors declare that they have no conflict of interest.

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