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# Transhumance in the Tigray Highlands (Ethiopia)

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Transhumance, the seasonal movement of herds occurring between two points and following precise routes repeated each year, is practiced on a broad scale in the open field areas of Tigray (North Ethiopia). This article presents a

characterization of the practice, factors that explain its magnitude, and recent changes. Eleven villages were selected randomly, semistructured interviews were conducted, and data on the sites were collected both in the field and from secondary sources. The transhumance destination zones are characterized as better endowed with water and fodder resources, essentially due to their great extent. The sample villages can be classified into three groups: annual transhumance (average one-way traveling distance 8.1 km), home range herding (average traveling distance 2.2 km), and

keeping livestock near homesteads. Movements are basically induced by the fact that there is little to no space for livestock near the villages during the crop-growing period—not by the significantly different temperature or rainfall conditions in the grazing lands. Adults will only herd the flocks when the distance for transhumance is great or considered unsafe; otherwise, young boys tend the livestock for the entire summer rainy season. Faced with social (schooling) and technological (reservoir construction and establishment of enclosures) changes, transhumance in Tigray has adjusted in a highly adaptive way, with new routes being developed and others abandoned. Transhumance does not lead to major conflicts in the study area even when livestock are brought to areas that belong to other ethnic groups (Afar, Amhara).

**Keywords:** Home range herding; grazing grounds; grazing rights; livestock; oxen; rangeland; Ethiopia.

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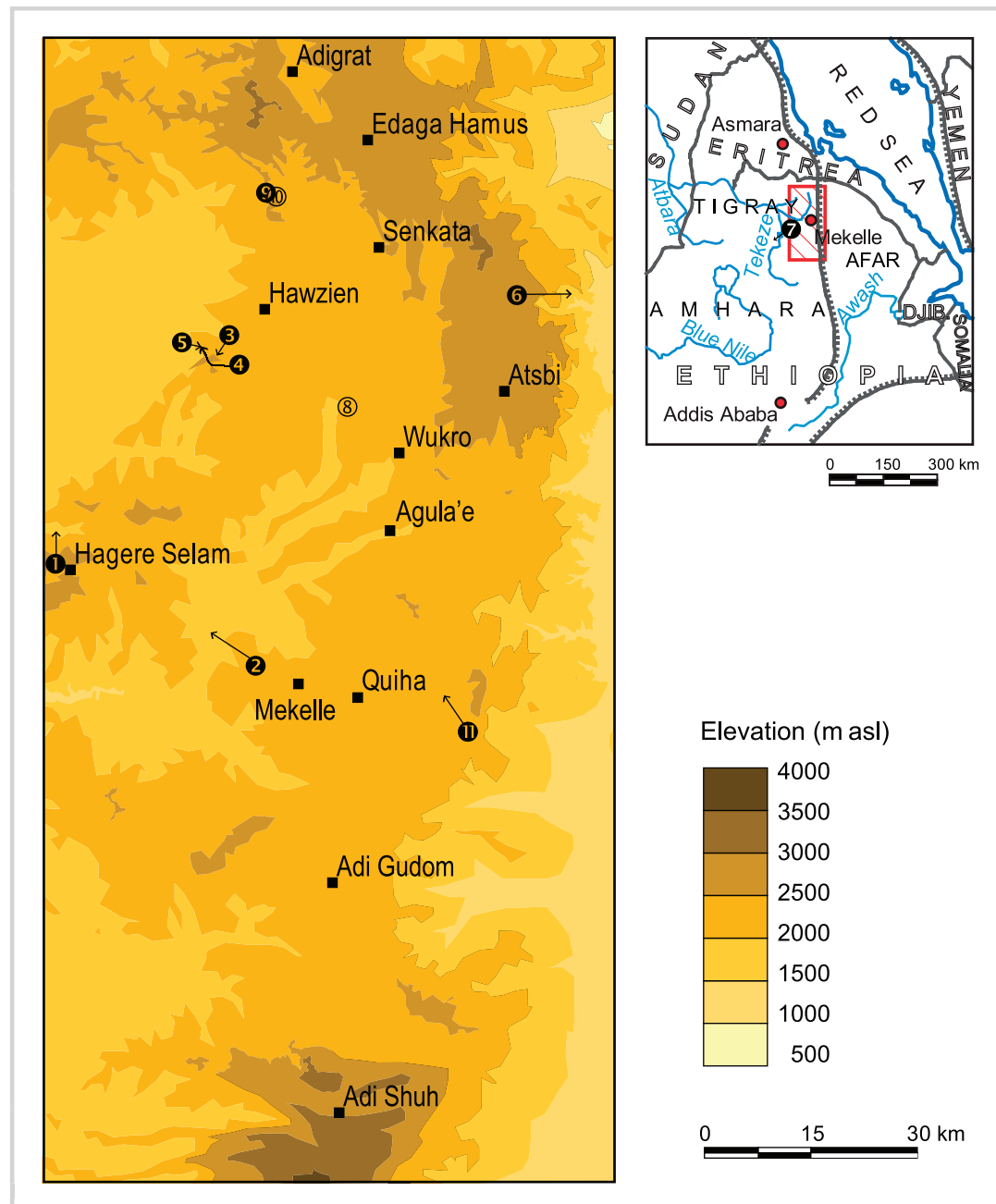
## Introduction

As in many other parts of eastern Africa, livestock are an important component of the agricultural system in the Tigray highlands (North Ethiopia). In the crop-growing season, transhumance is practiced on a broad scale in the open-field areas of Tigray, as farmland and stubble can no longer be accessed by livestock (Figure 1). By transhumance we mean the practice of “herd movements that are seasonal, occurring between two points, following very precise routes and repeated each year” (DGCID 2001). Studies of transhumance generally show that this practice is an adaptation to spatial and temporal variability in climatic conditions, for instance, in most European mountains (Dodgshon and Olsson 2007), in central parts of North America by indigenous populations and by settlers (White 1926; Stoffle and Evans 1976), in southern Africa (Rohde and Hoffman 2008), and in the Sahel (Zonneveld 1984; Banoin and Jouve 2000).

Whereas some researchers make an explicit or implicit link between pastoralism and transhumance (Fark-Grüninger 1995; Cour 2003; Hoffman and Rohde 2007), the latter is commonly practiced by sedentary populations. As such, transhumance should not be

confused with pastoralism, as it is part of a system that combines the seasonal movement of livestock with permanent arable agriculture (Evans-Pritchard 1940; Johnson 1969; Zonneveld 1984; Jones 2005). This distinction is important, because the majority of studies concerning transhumance in Ethiopia relate to peripheral pastoral areas (Coppock 1994; Kamara et al 2004), and the terminology often seems improperly used. In Ethiopia (Tigray) and Eritrea, transhumance has been associated with human and livestock disease hazards (Roundy 1976; Gebretsadik et al 2007), threats to riverine forests (Connelly and Wilson 1996), and collective action in community management of grazing lands (Benin and Pender 2006). Here we first characterize transhumance practices in the Tigray highlands in terms of organization, importance, composition of the herds, transhumance destination zones (TDZs), routes, rights of use, and conflict management. We also analyze whether the scope of the practice is induced by regional variations in climatic conditions and whether recent developments (schooling, enclosure over large parts of the villages’ territories, construction of reservoirs and agricultural intensification) have led to changes in the practice of transhumance.

**FIGURE 1** Location map with schematic representation (arrows) of transhumance and home range herding movements. Numbers in clear circles correspond to villages that do not engage in these practices. Names of villages: 1: Adi Geza'eti, 2: Kokolo, 3: Megab, 4: Korkor, 5: Da Tsimbia, 6: Agewo, 7: Hidmo, 8: Antshel, 9: Gobo Dogu'at, 10: Gabien, 11: Akeza.



## Study area

The varied lithologies of the Tigray Mountains (volcanic, sandstone, limestone, and metamorphic rock) and surrounding areas ( $10^5 \text{ km}^2$  in extent and from 1000 to 3000 m), and the subhorizontal structural relief that they

induce, are the basis for zonation of the soils in the study area. Lithology and position on the slope largely determine the soils' spatial distribution and their utilization (Nyssen et al 2008a). Average annual rainfall ranges between 500 and 900  $\text{mm yr}^{-1}$ , mostly concentrated in the summer rainy season (end of June to

end of August). Young soils are dominant owing to active erosion processes. The permanent mountain agricultural system of Tigray may be characterized as a “grain-plough complex” (Westphal 1975) with a cropping pattern that is adjusted to the various soils present in each catena. Cereals are the dominant crops, and the farming system is geared to maximize yields.

Agriculture in the Tigray highlands consists exclusively of small-scale family farms. A land tenure regime was introduced in the 1980s and has led to broad equality in the size of landholdings (Hendrie 1999). On average, the families in the study area farm two or three parcels of cropland, with a combined area of 0.5 to 2 ha. Grassland, rangeland, and exclosures are communally owned. Cultivated crops include common cereals such as barley (*Hordeum vulgare*) and wheat (*Triticum* sp.), as well as tef (*Eragrostis tef*), a cereal with very fine grains endemic to Ethiopia. Leguminous crops are also important. With a rotation intensity of 0.91—that is, the ratio of cropped area to cropped plus fallow—and the existence of clearly demarcated fields (Nyssen et al 2008a), the agricultural system in the Tigray highlands can be characterized as a permanent upland farming system (Ruthenberg 1980) practiced by a sedentary population.

Livestock are predominantly cattle (especially oxen) and also include sheep, goats, donkeys, and mules. An average family owns 1 or 2 oxen, 5 to 6 goats or sheep, and sometimes a donkey. An exceptionally rich farmer may possess 6 or 8 oxen, 20 or 30 goats and sheep, and 3 to 4 mules or donkeys (Naudts 2002). Livestock-keeping is part of the permanent upland system (Ruthenberg 1980). It is very important for farmers, especially as a source of energy: oxen are essential for the production system, being used for plowing and threshing (Solomon et al 2006), and donkeys are used to transport heavy loads. Manure commonly substitutes for firewood. Livestock, especially sheep and goats, are also considered as insurance for difficult periods. The production of meat and milk are only of secondary importance for most farmers. Yet it must be considered that 475,321 smallholder farmers in Tigray manage approximately 844,845 oxen (CSA 2006). Overall, livestock productivity is low in Ethiopia due to the shortage and poor quality of fodder (Benin et al 2006).

Since no forage crops are grown, livestock are allowed on all land where grazing is not forbidden. Fallow land and harvested cropland are also used for grazing (“stubble grazing,” Figure S1; <http://dx.doi.org/doi:10.1659/mrd.00033.S1>). Increasingly, as part of a bold effort to protect the most endangered areas, notably on steep slopes and in eroded areas, such lands are being converted into exclosures, that is, lands under strict management and often policed by the community, where grazing is prohibited, where woodcutting is allowed only in certain cases and under strict regulations, and where annual grass-cutting is organized (Descheemaeker et al 2006).

## Study methods

During 10 years of fieldwork and multidisciplinary research, we became acquainted with the study area, its inhabitants, and the agricultural system, including transhumance practices. For this particular survey, villages were selected where other research has also been conducted (Nyssen et al 2006, 2008b; Munro et al 2008; Segers et al 2008; Fredu et al 2009) and where we had good relations with the communities (Tables 1 and 2). This allowed semistructured interviews to be conducted confidently with village dwellers and shepherds. Issues addressed during these interviews for the purposes of understanding and characterizing transhumance concerned herd composition, organization, routes and TDZs, use rights, and occurrence and management of conflicts.

A systematic inventory included field observations and secondary data collection. In the field, the general environmental setting, lithology, topography, and water availability were assessed and geographical coordinates were recorded using a global positioning system. Topographic maps at a scale of 1:50,000 and 1:250,000 (EMA 1979, 1996) were analyzed for elevation and distances. Data on landholding size, population, and oxen density were obtained from the Ethiopian Central Statistical Agency (CSA 2006). Such data are available at the level of *woredas* (districts in the study area ranging from 700 to 2000 km<sup>2</sup>), but not at the level of municipalities or villages. Detailed data on densities of sheep and goats are not available at all. Average yearly rainfall, average August rainfall (month with greatest rainfall and climax of transhumance activities), and average yearly temperature were interpolated using NewLocClim (FAO 2008). Temperature was estimated along a vertical gradient with neighboring stations, and rainfall was exclusively interpolated along a lateral gradient, as no correlation exists in the study area between elevation and rainfall (Nyssen et al 2005).

We used Landsat ETM+ satellite imagery (especially Bands 3 and 4) taken in January 2000 (middle of the dry season) and the derived Normalized Difference Vegetation Index (NDVI) to assess biomass availability around the villages and in TDZs. NDVI is used universally as a measure of greenness (Lillesand and Kiefer 2000). The NDVI values were obtained using Idrisi32 Release Two software. This vegetation index takes the form

$$NDVI = \frac{NIR - R}{NIR + R} \quad (1)$$

where NDVI value ranges from −1 (no vegetation) to 1 (dense vegetation), NIR = near-infrared reflectance, and R = red reflectance.

Average NDVI values were calculated for 500 m × 500 m squares in every village and TDZ. Recent changes

**TABLE 1** Characteristics of the 11 villages, and their TDZs, used in the study (averages  $\pm 1$  SD).

Characteristics	Villages <sup>g)</sup>	TDZ <sup>h)</sup>
Elevation (masl)	2226 $\pm$ 401	1948 $\pm$ 487
Average annual rainfall <sup>a)</sup> (mm)	755 $\pm$ 88	751 $\pm$ 93
Average August <sup>b)</sup> rainfall <sup>a)</sup> (mm)	208 $\pm$ 41	193 $\pm$ 71
Average annual temperature <sup>c)</sup> ( $^{\circ}$ C)	17.70 $\pm$ 3.30	19.10 $\pm$ 3.70
NDVI value (27 Jan 00) <sup>d)</sup>	-0.20 $\pm$ 0.05	-0.19 $\pm$ 0.09
Average landholding size <sup>e)</sup> (ha)	1.02 $\pm$ 0.38	
Agricultural population density <sup>f)</sup> (km <sup>-2</sup> )	104 $\pm$ 25	
Oxen density <sup>f)</sup> (km <sup>-2</sup> )	22 $\pm$ 4	
Distance from village (km)	—	5.30 $\pm$ 4.70
Absolute difference in elevation with village (m)	—	324 $\pm$ 331

NDVI, Normalized Difference Vegetation Index.

<sup>a)</sup> As interpolated using NewLocClim software (FAO 2008)—polynomial interpolation along a horizontal gradient (extrapolation not allowed) from data of maximum 10 nearest stations, maximum 100 km away.

<sup>b)</sup> As the transhumance from Hidmo village to Chow'eh TDZ takes place in the dry season, the average February rainfall was incorporated in the comparison.

<sup>c)</sup> As interpolated using NewLocClim software (FAO 2008)—linear inter- and extrapolation along a vertical gradient from data of maximum 10 nearest stations, maximum 100 km away.

<sup>d)</sup> Derived from Landsat ETM+ satellite imagery.

<sup>e)</sup> Calculated at district level, using data from CSA (2006).

<sup>f)</sup> Calculated at district level, using data from CSA (2006).

<sup>g)</sup> Full details in Table S1 (<http://dx.doi.org/doi:10.1659/mrd.00033.S1>).

<sup>h)</sup> Full details in Table S2 (<http://dx.doi.org/doi:10.1659/mrd.00033.S1>).

(schooling, catchment management activities, and agricultural intensification) were also assessed, especially in relation to routes used for transhumance, as well as to the magnitude of the practice.

## Results

Unlike transhumance in the Mediterranean region (Aitken 1945; Puigdefabregas and Fillat 1986), transhumant livestock movements in Tigray generally involve distances not greater than 20 km, and daily contact is maintained with the village. Villages that do not have access to sufficiently wide nearby pasture grounds organize seasonal transhumance to a distant zone during the crop-growing period in the summer rainy season. The presence of livestock near crops is thus avoided, and grass on nearby pastures is allowed to grow and is saved for use later in the season. Transhumance of cattle is the first concern; sheep and goats may be added to the flock. Young boys remain with the herds day and night. Their work includes bringing the herd to the best grazing grounds and watering it every day or every two days. In the evening some adult men, each one in his turn, join the herd to supervise nighttime protection of livestock and the shepherds; they also bring food to the children. The TDZ is typically

called *bereha*, or “desert.” Table 1 summarizes some characteristics of villages and their TDZs, while detailed inventories are presented in Tables S1 and S2 (*Supporting Information*; <http://dx.doi.org/doi:10.1659/mrd.00033.S1>).

## Transhumance and other livestock-keeping practices

Some typical practices related to transhumance in Tigray are described in this section.

Herds in the village of Adi Geza'eti (2580 m) are brought each summer to the gorge of the River Tsali (1930 m), where riparian vegetation exists (Figure 1, village 1). The young shepherds establish enclosures and places to sleep, if possible in rock shelters, but if not, in the open air. The first to arrive choose the best places. The shepherds remain there until after the harvest, when the oxen are needed for threshing operations and when the herds are fed by stubble grazing. As this takes place during summer school holidays, young boys who are in school join with those who are not. This is the most frequent method of practicing transhumance in the area.

In Kokolo village (2060 m), the herds are taken to the Geba River valley (1680 m) (Figure 1, village 2). This case is very similar to the previous one, with the exception that one of the village families has chosen to dwell in the valley and has occupied the best rock shelters and transformed them into permanent cattle sheds.



The villages around Mount Kemer (2440 m) in the Gueralta plain have different livestock migration patterns, depending on accessibility to the mountain, which is composed of a foot slope, a very high cliff, and an undulating top plateau (Figure 2). From Korkor and Da Tsimbia (2000 m) (Figure 1, villages 4 and 5), the herds are led toward the upper slopes of Mount Kemer (2200–2300 m), where the land is too rugged to be occupied by farmland. During the rainy season, there are many water holes and there is much lush vegetation. Whereas the herds from Da Tsimbia usually return to the homesteads for the night, those from Korkor have to be taken through a difficult mountain pass and hence are kept overnight on the grazing lands. The flocks belonging to the slightly urbanized Megab (2050 m) (Figure 1, village 3) are only taken to the foot slopes of Mount Kemer, reportedly because many farmers have off-farm income activities that do not allow for careful follow-up of livestock in transhumance. People from this area do not bring the livestock to the lowland areas more to the west, as they maintain that “that land belongs to other villages.”

The herds of Agewo (2840 m) descend the western escarpment of the Rift Valley (Figure 1, village 6), which is a day’s walk. This is a region with seasonal springs, and it is much less populated, “a shared territory in which Afars and Tigrayans are involved in both intensive and extensive interaction” (Kelemework 2006). Livestock are kept there throughout the rainy season by adult men: conflicts with the Afar are not frequent, but memories of past fighting and cattle raiding, such as those described by McCann (1985) and Kelemework (2006), are still recalled.

Hidmo (1450 m), a village in the lowlands with high temperatures and water shortages, is located some 9 km from Tekezze River, one of the major tributaries of the Nile (Figure 1, village 7; Figure S2; <http://dx.doi.org/doi:10.1659/mrd.00033.S1>). The river flows in a deep gorge, the slopes and shoulders of which are used as a TDZ. Rangelands are much wider across the river on its west bank, and the inhabitants have developed a bimodular transhumance system. Throughout the dry season livestock are herded across the river to Chow’eh, an area in the Amhara region, a day’s walk from the village. The flocks are herded by adult men on a rotational basis, but not by children, as Chow’eh is far from home and both the river crossing and the livestock watering are unsafe owing to the presence of crocodiles. In addition, many children have started to go to school in recent years and dry season transhumance here takes place in the middle of the school year. The magnitude of transhumance in the dry season depends on the previous year’s harvest: when there is little straw, most people will bring their livestock there. Otherwise, only half of the households participate in transhumance. Conflicts with the Amhara cultivators on the other side of the river are rare. Villagers stated: “They quarrel only when too many livestock are brought. It is especially the youngsters who quarrel. We generally

**FIGURE 2** Partial view of Mount Kemer, from Da Tsimbia. The TDZ is located behind the ridge. Note the presence of small remnant forests on inaccessible flats. (Photo by Jan Nyssen)



communicate in Amharic, though most elder people also know Tigrinya. There are many cross-marriages, girls from Hidmo who marry at the other side of the river.” Quarrels over land use rights do not seem to have an ethnic flavor—they are rather similar to what may occur between neighboring villages within Tigray.

In the summer rainy season, livestock are herded on the eastern, nearby banks of Tekezze River, which at that time is impossible to cross. The shepherds are young boys, and the practice is very similar to the one described for Kokolo and Adi Geza’eti. On the left bank of the Tekezze, the Amhara also bring their livestock down to the river. They never need to cross, as there is more grass on that side.

As far as can be remembered, people from Antshel (Figure 1, village 8) have never practiced transhumance. Until some 12 years ago, livestock were taken daily for grazing to Bereha Antshel, the 250-m high escarpment that overlooks the village, and brought home in the evening. In recent years, these slopes have become exclosures and the area has changed dramatically (Figure 3). Vegetation has grown, infiltration is enhanced, and springs have developed. As every potential rangeland area has become an exclosure, livestock are kept in and near the homesteads; grass is cut from the closed areas and pure water is available in newly arisen rivulets.

In Gobo Dogu’at (2690 m) and Gabien (Figure 1, villages 9 and 10), separated by a 200-m high cliff, livestock are not subject to transhumance. The herds of Gabien village are kept there, feeding year-round on edaphic grasslands on the wetlands in the center of the village. Gobo Dogu’at’s livestock are taken down daily to the valley in the lower part of the village near Gabien. Despite the fact that an ancient, man-made foot tunnel provides access to bushy areas in the west, livestock are not sent there because, it was reported, “those areas belong to another village.”

**TABLE 2** Typology of transhumance practices<sup>a)</sup> in the study area (averages  $\pm 1$  SD). (Table extended below.)

Type of practice	Villages	Distance to TDZ (km) <sup>b)</sup>	$\Delta z$ , Difference in elevation (m)	Difference <sup>c)</sup> in rainfall (mm) <sup>d)</sup>	
				Annual	August <sup>e)</sup>
Transhumance to TDZ	Adi Geza'eti, Kokolo, Korkor, Agewo, Hidmo, Akeza	8.1 $\pm$ 4.0 (seasonally)	491 $\pm$ 332	-6 $\pm$ 48	+ 4 $\pm$ 6
Home range herders	Megab, Da Tsimbia, Gobo Dogu'at	2.2 $\pm$ 0.8 (daily)	183 $\pm$ 115	-2 $\pm$ 3	0 $\pm$ 2
Livestock kept in the village	Antshel, Gabien	$\sim 0.0$	$\sim 0.0$		

**TABLE 2** Extended.

Difference in yearly temperature ( $^{\circ}\text{C}$ ) <sup>c),f)</sup>	Difference in NDVI <sup>c)</sup>	Typical difference in water availability between village and pasture <sup>g)</sup>	Most common pattern with respect to lithology
+3 $\pm$ 3	0.01	(B or C) to (A)	Same lithology, or transhumance to "less fertile" lithology; often to sandstone
0 $\pm$ 1	0.04	(C) to (A or B)	Generally to "less fertile" lithology, sandstone
		(A) to (A)	Within same lithology

NDVI, Normalized Difference Vegetation Index.

<sup>a)</sup> In every village it is the norm to participate in the mentioned practice—nonparticipation may be due to socioeconomic problems (no children available, disease, lack of money to hire somebody); full details in Table S3.

<sup>b)</sup> All distances are Cartesian distances—real walking distance is 1.5 to 2 times the Cartesian distance.

<sup>c)</sup> Positive difference indicates that the value of this parameter is higher in the TDZ than in the village.

<sup>d)</sup> As interpolated using NewLocClim software (FAO 2008)—polynomial interpolation along a horizontal gradient (extrapolation not allowed) from data of maximum 10 nearest stations, maximum 100 km away.

<sup>e)</sup> February data were used for transhumance from Hidmo to Chow'eh.

<sup>f)</sup> As interpolated using NewLocClim software (FAO 2008)—linear inter- and extrapolation along a vertical gradient from data of maximum 10 nearest stations, maximum 100 km away.

<sup>g)</sup> Water availability in villages and pastures was evaluated as (A) sufficient water available throughout the year for humans and livestock; (B) water available throughout the year but sometimes long waiting times, especially for livestock; (C) water availability is critical.

Though located in a situation on the Rift shoulder similar to Agewo, the farmers of Akeza (Figure 1, village 11) do not take their livestock down the Rift Valley escarpment, simply because there are no areas with sufficient availability of water. Previously, a few springs and some pond water in the rainy season allowed livestock to be kept in the village. Transhumance started only in recent years, after the Hashenge earth dam and reservoir were built in 1997 within the plateau, some 5 km from the village (Tadesse et al 2008). Presently, around half of the village stock is brought there during the rainy season and remains there the whole season, herded by children.

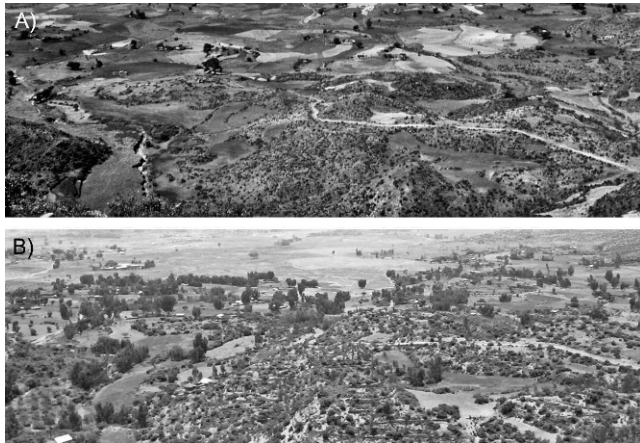
#### Comparison of village surroundings and TDZs

Unsurprisingly, the TDZs are found to be better endowed with water and fodder resources. Mostly they have springs or a river. NDVI values measured during the dry season when farmlands bear no crops (Table 1) are  $-0.20 (\pm 0.05)$

for the immediate village surroundings and  $-0.19 (\pm 0.05)$  for the TDZ; there is no significant difference. The availability of fodder is instead related to the extensiveness of the TDZ. As they are usually located downslope from the villages, TDZs are on average  $1.5^{\circ}\text{C}$  warmer; yearly and summer rainfall are very similar in the villages and their respective TDZ, except for Agewo, where livestock are brought to a remote and less rainy area at the margins of the Danakil Desert (Table S1; <http://dx.doi.org/doi:10.1659/mrd.00033.S1>). Furthermore, there is an additional good reason to go to the TDZ during the rainy season: overall, soils are sandy and shallow there (Table 2) and temperatures are higher, so that herbaceous vegetation is at its most plentiful during the rains.

Resident human and livestock population densities are lower in the TDZs. When the routes stay within the same *woreda*, such differences can only be observed anecdotally, as high-resolution census data are not available. In a few

**FIGURE 3** An area where livestock movements have been abandoned has undergone important changes between 1975 and 2007. The former grazing lands (lower part of the photographs) have been closed and livestock are fed on grass harvested from these exclosures. (A) Antshel in 1975. (Photo by Neil Munro); (B) Antshel in 2007. (Photo by Jan Nyssen)



cases, transhumance leads to remote boundary areas between *woredas*, with low population densities. In the case of Hidmo, livestock are brought to another *woreda* in the dry season, which has less land suitable for agriculture and hence small landholdings, less population, and lower oxen densities.

## Discussion

### Typologies of transhumance

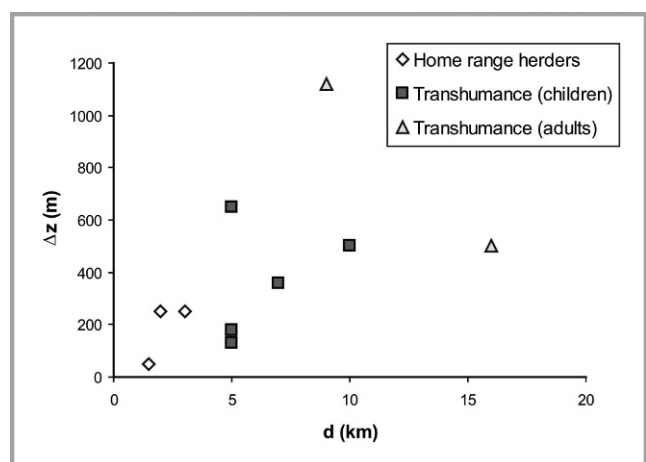
With respect to transhumance practices, the villages studied can be classified into three groups: those where transhumance is practiced; those where daily movements with livestock are back and forth to the grazing grounds, the “home range herders” of Baker and Hoffman (2006); and those where livestock are kept near homesteads (Table 2; Figure 4). In all villages that practice transhumance, a proportion of the farmers do not participate in the seasonal livestock movements but rather bring their livestock daily to nearby grazing grounds. Home range herders daily travel an average distance of 2.2 km, whereas transhumance takes place over an average distance of 8.1 km. Furthermore, average difference in elevation ( $\Delta z$ ) is much greater in the case of transhumance. Based on the distance and difficulty of the terrain (and its proxy,  $\Delta z$ ), farmers decide to keep livestock on the grazing grounds during the whole cropping season. Both distance from the village and the difficulty of the terrain are very straightforward parameters that explain whether a village practices home range herding or transhumance and, in the latter case, whether the flocks are herded by children or adults (Figure 4). Yet transhumance practices in Tigray may be characterized as “low amplitude transhumance” (Banoïn and Jouve 2000): in contrast to situations in the

Mediterranean (Aitken 1945; Cleary 1987; Puigdefabregas and Fillat 1986) or in the Sahel (Banoïn and Jouve 2000; Green and Tchinné 2004), transhumance movements in the Tigray highlands follow relatively short routes, particular for every village, rather than lengthy trails.

Water availability is generally better in the more distant TDZs (which are often close to deeply entrenched rivers) than in the nearby areas where the home range herders go. TDZs are located on lithology (often sandstone) that generally produces less fertile soils, which is a major reason, besides topography, why farmland was not established there. The average NDVI values tend to indicate that there is no significant difference in vegetation cover between the village surroundings and the TDZ. However, high NDVI values in the villages are induced by the presence around homesteads of plantations growing (unpalatable) eucalyptus. Furthermore, the attraction of a TDZ is not related to good vegetation cover in the first place, but to its wide extent and free access. This is in contrast to the village surroundings, where the few rangelands in the rainy season are highly fragmented by farmlands out of bounds for livestock. Methodologically, the use of a vegetation index such as NDVI in satellite image interpretation has proven not to be a good tool to locate a potential TDZ, as its attractiveness is governed by relative remoteness, wideness, and water availability.

Livestock are typically kept in the village if no TDZs with water are within reasonable distance. This may be the case owing to water scarcity on the available grazing grounds (eg Akeza before reservoir construction), or because grazing lands have become exclosures, in which case livestock are kept near the house and fed on harvested grass (for instance, in Antshel). Transhumance in Tigray is thus basically related to availability of water and especially range space during the cropping season, and not by significantly

**FIGURE 4** Livestock herd movements as a function of distance from the village ( $d$ ) and accessibility (represented by its proxy, difference in elevation [ $\Delta z$ ] between the village and its [summer] TDZ).





**TABLE 3** Contrast in NDVI values between village grazing areas and distant TDZs where transhumance occurs (Agewo and Hidmo) or does not occur (Da Tsimbia and Gobo Dogu'at).

Village	Type of practice	(Potential) TDZ	NDVI value <sup>a)</sup> in village	NDVI value <sup>a)</sup> of TDZ	Difference in NDVI
Agewo	Transhumance to TDZ	Awī Fiso, 9 km away, boundary to Afar region	−0.20	0.03	0.23
Hidmo	Transhumance to TDZ	Chow'eh, 16 km away, across Tekezze River, in Amhara region	−0.24	−0.30	−0.06
Da Tsimbia	Home range herders	May Negad, potential TDZ, 6 km away, in neighboring Tigray village	−0.26	−0.23	0.03
Gobo Dogu'at	Home range herders	Shelewa, potential TDZ, 4 km away, in neighboring Tigray village	−0.24	−0.19	0.05

<sup>a)</sup> On 27 January 2000.

different temperature or rainfall conditions, which is the case for transhumance in other areas of Africa (Zonneveld 1984; Banoin and Jouve 2000; Rohde and Hoffman 2008), or in mountain areas of Europe (Aitken 1945; Puigdefabregas and Fillat 1986; Dodgshon and Olsson 2007) or North America (White 1926; Stofle and Evans 1976).

### Transhumance and conflicts

It is striking that villages around Megab and Gobo Dogu'at do not bring their livestock to nearby areas inhabited by Tigray kinsmen, because, they say, “the land belongs to another village,” whereas Hidmo and Agewo do not hesitate to enter Amhara or Afar territory (Table 3) while generally avoiding conflicts. This suggests that conflicts are related to the availability of grass and grazing space, rather than being purely ethnic in character. Official proposals to demarcate grazing grounds between Tigray and Afar have been rejected by both groups as they “preferred joint use of available resources in harmony” (Kelemework 2006). Important here, besides the carrying capacity (Zonneveld 1984), is that both groups have partially different seasonal grazing patterns, the Tigrayans going down from the highlands during the summer rainy season and the Afar nomads coming up from the lowlands following a less rigid temporal pattern related to extremely erratic rainfall in the Danakil Desert margins.

Table 3 shows, for instance, that potential TDZs for Da Tsimbia and Gobo Dogu'at are better endowed with vegetation than are the villages. However, around each of these TDZs are several other villages, the inhabitants of which would not be happy to see additional livestock arrive in search of pasture.

### Changes in practice

Transhumance reacts in a highly adaptive way to social and technological changes in society. The construction of an earth dam some 5 km from Akeza encouraged some farmers to start transhumance activities. On the other hand, reservoir building inside the village of Agewo did not stop transhumance to its traditional, distant TDZ, essentially because rangeland is limited around the reservoir. In Antshel, the enclosure of previous rangelands has led to abandonment of home range herding, and villagers claim that grass harvested nowadays from that area and the improved availability of water are largely sufficient for their herds, which are now smaller in number and also healthier.

Total net enrollment ratio in primary education in Ethiopia increased from 26% in 1991 to 75% in 2007 for boys and from 19% to 69% for girls (UNSTATS 2009). As most transhumance activities take place during summer school holidays, increased schooling does not affect the practice of transhumance. It is not uncommon to see young herders studying textbooks for the upcoming school year. Football, which has been introduced in schools, was also seen to have increasingly supplanted the traditional game of *qarsa* in the TDZs. In the case of Tigray, transhumance seems compatible with schooling.

The fact that the Ethiopian government has generally resisted any pressure for large-scale land privatization and has tried to strengthen tenure rights for individual smallholders (Hennebert 2006; Kanji et al 2006) has led to a near-absence of large, private range grounds that could pose obstacles to transhumance routes as, for instance, in South Africa (Baker and Hoffman 2006; Hoffman and Rohde 2007; Rohde and Hoffman, 2008).

## Conclusions

To allow sowing of crops on farmland during the rainy season, stubble grazing is stopped and the herds on the Tigray highlands are sent to remote areas (valley bottoms or upper slopes of mountains) where grass and water are available. Such altitudinal movements are basically induced by the fact that there is little to no space for livestock near the villages. As such, transhumance in the North Ethiopian highlands fully accords with Johnson's (1969) definition: "Although pastoral activities are one of the concerns of a transhumant community, agriculture nearly always remains the dominant interest. In other words, pastoral movements are limited in scale, usually take place in one valley system, and are undertaken by only a small proportion of the total population. None of these features are shared by pastoral nomads."

Faced with social (schooling) and technological (reservoir construction and establishment of exclosures)

change, transhumance in Tigray has adjusted itself in a highly adaptive way, with new routes being developed and others abandoned. In several villages, there is an increasing trend toward feeding livestock at home using grass harvested from exclosures. Interestingly, in the study area, transhumance seems not to lead to major conflicts (unlike in the past—McCann [1985]) even if livestock are brought to areas belonging to other ethnic groups. Conflicts are avoided by not bringing livestock to particular areas if there is a lack of biomass. Ethnicity does not play a role here, whereas environmental and socioeconomic processes and changes do.

Because this study, a first of its kind in Ethiopia, is mainly limited to characterizing the practice of transhumance and analyzing its determinants, future geographical research could include, for example, spatial modeling of the practice. This may lead to the prediction of areas that could be affected by transhumance in the near future under various assumptions of oxen density and agronomic practices.

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