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Ideal Free Distributions of Mobile Pastoralists in Multiple Seasonal Grazing Areas

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Abstract

The pastoral system in the Far North Region of Cameroon is best described as an open system in which mobile pastoralists have open access to common-pool grazing resources. We hypothesized that there is a self-organizing management system of open access to common-pool grazing resources and predicted that we would find an Ideal Free Distribution (IFD) of mobile pastoralists within seasonal grazing areas. In this paper we used mobility data and remote sensing data from two seasonal grazing areas at the end of the dry season in three consecutive years to evaluate that hypothesis. We found evidence of an IFD in the two seasonal grazing areas of the Logone Floodplain and the Lake Maga area. These findings offer further support for our hypothesis that there is a complex adaptive system in which pastoralists distribute themselves effectively over available grazing resources.

Key Words: behavioral ecology, common-pool resources; complex adaptive system, Ideal Free Distribution, pastoral systems

INTRODUCTION

The pastoral system in the Logone Floodplain in the Far North Region of Cameroon is best described as an open system in which mobile pastoralists have open access to common-pool grazing resources (Moritz et al. 2013b). Every year thousands of pastoralists from different ethnic groups from Niger, Nigeria, and Cameroon move into the floodplain with more than 200 000 cattle to spend a considerable part of the dry season. We have found that pastoralists adjust the grazing pressure to the available grazing resources in the floodplain, no major conflicts among pastoralists, and no evidence of a tragedy of the commons (Scholte et al. 2006).

We have argued that this pastoral system is best understood as a complex adaptive system, which is "a system in which large networks of components with no central control and simple rules of operation give rise to complex collective behavior, sophisticated information processing, and adaptation via learning or evolution" (Mitchell 2009). Examples of complex adaptive systems are ant colonies (Gordon 2010), immune systems (Mitchell 2009), and irrigation systems (Lansing 2006).

In the case of the pastoral system in the Far North Region, there are no rules among mobile pastoralists regulating access to common-pool grazing resources and no collective and/or centralized decision making about movements and campsite selection. Instead, individual pastoralists (components) make their own independent and autonomous decisions about where to move, set up their camps, and graze their animals (rules of operation). In their decision making pastoralists consider both the distribution of resources and other pastoralists (information processing) and are coordinating their movements with other pastoralists (adaptation). This coordination occurs in a dynamic environment in which processes of grazing, burning, and desiccation continually change the distribution of resources and, through a self-organizing process, the distribution of pastoralists.

We have argued that in this complex adaptive system of open access to common-pool grazing resources we would find evidence of an Ideal Free Distribution (IFD), characterized by a positive correlation between use of camp zones by herds and available grazing resources within camp zones, in multiple seasonal grazing areas within the larger Chad Basin (Moritz et al. 2013b). In an earlier study we found support for an IFD of mobile pastoralists within the Logone Floodplain, Cameroon, at the beginning of the dry season (Moritz et al. 2014). However, questions have been raised about whether the Logone Floodplain is a unique case and to what extent our findings apply to other grazing areas. Here we use data from the Logone Floodplain (*Yaayre*) and the Lake Maga area (*Ndiyam Shinwa*) at the end of the dry season in three consecutive years (2010–2012) to examine whether there is an IFD within multiple seasonal grazing areas. We have selected these two areas because they are two of the most important grazing areas in the dry season for mobile pastoralists in the Far North Region.

The IFD model predicts how animals should distribute themselves over resource patches or habitats (Fretwell and Lucas 1969; Sutherland 1996). The two main assumptions in the IFD model are 1) individuals have perfect knowledge about the resource quality and quantity of each patch (ideal assumption) and 2) individuals are free to move to any patch (free assumption). When those conditions are met, the theory predicts that individuals should be distributed such that no individual can gain more resources by moving to a different patch. Quantitative predictions of ideal free models depend on the assumptions specific to each model. However, we can make

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three general predictions about IFDs when resources deplete slowly. First, use of a patch should be positively correlated with the total resources available in the patch (which is a function of resource density and patch area). Second, if not all patches are occupied, then occupied patches should have higher resource availability than unoccupied patches. Third, the variance in standing resource quality of occupied habitats should be lower than the variance in resource quality of unoccupied habitats, because herds will tend to deplete all occupied habitats to the same quality, while, in unoccupied habitats, current resource quality is unaffected by depletion.

The concept of the IFD has been used in behavioral ecology studies to examine habitat selection and foraging strategies of animals (Kennedy and Gray 1993; Sutherland 1996; Hamilton 2010), but recently it has also been used to study the mobility and settlement patterns of human populations (Kennett et al. 2006; Winterhalder et al. 2010), including mobile pastoralists (Scholte et al. 2006; Behnke et al. 2008, 2011). Pastoral systems provide an excellent case for examining IFD theory because the mobility and settlement patterns of pastoralists are primarily driven by spatiotemporal changes in the distribution of forage and water, even though the human dimension of pastoral systems means that nonforage constraints shape mobility and settlement patterns (Behnke et al. 2011).

Although pastoralists are likely neither perfectly ideal nor perfectly free to move, the pastoral system in the Far North Region does closely match these two main assumptions of the IFD. First, while pastoralists do not have perfect information, they have reliable information about the suitability of different habitats through a combination of scouting and information sharing within social networks. Second, access to common-pool grazing resources is best described as open access in that there are no regulations restricting access, which means that pastoralists are free to move to any habitat.

However, the pastoral system does not fit all of the assumptions of ideal free models (for a detailed discussion see Moritz et al. 2014). For example, pastoralists do not necessarily have similar preferences and assessment of habitats; their annual transhumance shapes and is shaped by habitual preferences for habitats on these orbits, so while they may be free to move, habitual preferences may influence the decision to move. Also, travel times between habitats are non-negligible. It may take herds 2 d to get from one end of the floodplain to another. Moreover, during these movements animals expend energy and have less time to graze (which they make partially make up by grazing longer at night during movement days). These and other challenges notwithstanding, we think that the IFD is an appropriate model to describe and explain habitat selection of mobile pastoralists within season grazing areas (Moritz et al. 2014).

Because pastoralists use mobility to exploit spatiotemporal variation in forage availability, they are continuously moving in response to ever changing distributions of common-pool grazing resources. One can examine pastoral mobility and distributions at multiple spatiotemporal scales ranging from daily herd movements (Butt 2009; Moritz et al. 2010; Moritz et al. 2012) to annual transhumance movements (Schareika 2003; Behnke et al. 2008) to decadal migratory drift (Stenning 1957; Boutrais 1996; Bassett and Turner 2007). We expect to find support for the predictions of the ideal free model at multiple spatiotemporal scales, when mobile pastoralists with complete information, freedom and ability to move, and independent and individual decision-making capabilities have open access to depletable common-pool grazing resources that are highly variable in space and time.

STUDY AREA AND POPULATION

Two phytogeographic zones characterize the Far North Region of Cameroon: Sudanian in the southern grades and Sahelian in the Logone Floodplain (*Yaayre*). The Logone Floodplain is flooded by the Logone River and its branches from September until November. After the water recedes in December, thousands of Arab and FulBe pastoralists from Cameroon, Nigeria, and Niger move with more than 200 000 cattle into the floodplain, making it one of the most important dry season grazing lands in the Lake Chad Basin (Seignobos and Iyébi-Mandjek 2000). Many remain there until the start of the rainy season in June, while others move to the floodplain further north (*Yaayre Woylare*), the floodplain in Chad (*Mayo Bori*), or the lakeside pastures around Lake Maga (*Ndiyam Shinwa*) (Fig. 1). Mobile pastoralists find nutritious regrowth and surface water in the Logone Floodplain and around Lake Maga far into the dry season, when surrounding pastures have dried up. At the start of the rainy season, pastoralists return to Diamaré plains or their respective countries.

The vegetation in the Logone Floodplain is relatively homogenous in terms of forage quantity and quality because of the extreme flatness of the area resulting in only limited variation in flooding depth and duration (Scholte 2007). There is only weak coupling between herbivores and vegetation as the predominantly perennial vegetation is controlled by flooding depth and duration and naturally protected against overgrazing because up to two-thirds of the biomass is stored underground. In addition above ground biomass is generally inaccessible to livestock during the 6 mo of the rainy and flooding seasons (Scholte 2007).

The lakeside pastures around Lake Maga were created in 1979 when the Cameroonian government constructed dikes along the Logone River and a dam between Guirvidig and Pouss to create a 400-km^2 reservoir, Lake Maga, for the irrigated rice cultivation project SEMRY II (Delclaux et al. 2010). The dam led to a significant reduction in flooding and regime shifts in the Logone Floodplain (Scholte 2005). However, the anthropogenic pastures around Lake Maga have now become a critical part of the mobile pastoralist system and are used by approximately 100 000 cattle at some point during the year.

The vegetation around Lake Maga is also relatively homogenous in terms of forage quantity and quality. But while the area is also extreme flat, the flooding dynamics in this anthropogenic floodplain are very different from those in the Logone Floodplain. The main hydrological difference is the duration of the flooding. In the Logone Floodplain the floods recede completely after about 5 mo (Jung et al. 2011), whereas the flooding in the Lake Maga pastures is controlled primarily by SEMRY II when it releases water for irrigating the rice fields. As a result, the water recedes very slowly, and the pastures in Lake Maga are flooded for a much longer period.