



Instantaneous intake rate of free-grazing cattle as affected by herbage characteristics in heterogeneous tropical agro-pastoral landscapes



Guillaume Chirat^{a,b,*}, Jeroen C.J. Groot^c, Samir Messad^a, François Bocquier^{b,d}, Alexandre Ickowicz^a

^a CIRAD, SELMET (Systèmes d'élevage méditerranéens et tropicaux) Group, 34060 Montpellier, France

^b INRA, SELMET Group, 34060 Montpellier, France

^c Wageningen University, Farming Systems Ecology Group, P.O. Box 563, 6700 AN Wageningen, The Netherlands

^d Montpellier SupAgro, SELMET Group, 34060 Montpellier, France

ARTICLE INFO

Article history:

Accepted 3 June 2014

Available online 11 June 2014

Keywords:

Functional response

Quantile regression

Heterogeneous landscape

Tropical cattle

Intake rate

Bite rate

ABSTRACT

Numerous territories of Sub-Saharan Africa are composed of a mosaic of very different landscape units: cropland, forest, and savannah. This spatial, but also temporal heterogeneity leads to complexity in the analysis of cattle intake behaviour. The instantaneous intake rate (IIR) is generally analysed in relation to forage biomass density (Bm), i.e. the functional response. We analysed the relationship between IIR and Bm and effects of other vegetation and animal factors for two herds of N'Dama cattle grazing freely during the dry season in the complex Sare Yoro Bana landscape located in the Kolda region in Southern Senegal. The available forages included crop residues (from rice, millet and maize), grass and hay, fruits and litter. The amount and quality of biomass declined throughout the dry season. The variation in IIR was large and could be attributed to differences in Bm (for 30%) and differed between seasons and vegetation types (also 30% of variation explained). Effects of animal characteristics such as wither height and requirements were significant but small compared to herbage-related factors. In the middle of the dry season (MDS) the IIR was higher than in the early dry season (EDS), probably due to better herbage prehensibility, whereas in the late dry season total herbage stocks were very low and also IIR was lower than in EDS and MDS. Two different relations were observed between IIR and the bite rate. In the EDS higher bite rate resulted in higher IIR, compared to an absence of such effect in later stages of the season indicating a compensation between ingestion rate and bite size. Based on these result, we conclude that the relation between intake rate and biomass density generally follows a type-2 functional response, modelled by a monotonically saturating function, but is strongly affected by many factors related to herbage palatability. Despite the inherent spatio-temporal complexity of the vegetation and the challenges in observations and data collection these relationships can be quantified for cattle grazing in a heterogeneous semi-arid landscape.

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1. Introduction

The agro-pastoral landscapes of numerous Sub-Saharan territories are heterogeneous. During the dry season, cattle herds browse and graze freely during the day wherein

* Corresponding author. Present address: CIRAD, 34 rue de la Villette, 34570 Pignat, France. Tel.: +33 434 35 30 21; fax: +33 467 54 56 94.
E-mail address: guillaume.chirat@yahoo.fr (G. Chirat).

they encounter a variety of cover types: cropland and pastoral margins (savannah and forest). Fields and patches in the fields are unevenly distributed across the landscape, in terms of biomass density, herbage quality and tensile resistance of the herbage. In addition to the spatial heterogeneity, the landscape changes during the dry season: bare soil follows crop residues carpets due to cattle intake, herbage quality in the savannah declines due to maturation, and flowering follows on from one tree species to another.

In such extensive ruminant production environments, cattle performance is strongly affected by feed availability and quality (Ezanno et al., 2003). From a research perspective, better understanding of cattle ingestive response to natural feed diversity and variability would support to develop and refine ruminant–vegetation interactions models, which could be used to inform decision-making in influence grazing management and ultimately improve cattle performance. Seeking to better understand the free-grazing behaviour in a landscape of Southern Senegal, we focused on a simplified approach aiming to take into account the numerous factors known to affect the short-term intake of cattle, by organising them into a hierarchy of importance. In other words, the present study does not deal with an analytical approach of physiological mechanics of food gathering and intake. The present study deals with correlations between simulations of intake rate from direct observations in the field and factors related to the animals and their environment, using easily measurable variables. The time-scale of observations was within periods of active grazing (minutes), named short-term intake. Factors affecting intake are mainly related to vegetation and animal characteristics and grazing management (e.g. Ungar, 1996; Drescher et al., 2006b).

Theoretically, short-term forage intake may increase with plant biomass according to an asymptotic type-2 functional response curve (Gross et al., 1993; Ungar, 1996): intake rate first increases linearly with forage density, then reaches an asymptotic rate. Indeed, at a given forage density, grasping would be limited by competition between ingestion and mastication or by bite volume and handling time due to plant characteristics (see Spalinger and Hobbs, 1992; Laca et al., 1994; Ginnett et al., 1999). Here, we describe a method to determine whether cattle have a type-2 functional response to herbage biomass, and to extend potentially this functional response, in an agro-pastoral environment. Based on a large amount of field data, this paper presents the potential effects of numerous factors like plant biomass, palatability (structural and chemical feed characteristics), animal motivation and grazing management, on instantaneous intake rates of N'Dama cows (*Bos taurus*) grazing freely during the dry season in a Sudanian agro-pastoral territory, dominated by rice straw and standing hay in the fallows and the pastoral margins.

2. Materials and methods

2.1. Site and agricultural system

The study was conducted during the dry season 2007–2008, in the village territory of Sare Yoro Bana

(12°49' N; 14°53' W), in the Kolda region in Southern Senegal. The climate is sub-humid with an average rainfall of 1100 mm year⁻¹, distributed during a unique rainy season (June–October). Average minimum and maximum temperatures are respectively about 19 and 37 °C for the dry season and 24 and 33 °C for the rainy season (Ickowicz and Mbaye, 2001). The agro-pastoral area is a mosaic of forest and savannah on the plateau and of savannah and crop fields on weakly inclined plains, so called pediments. Pediments are terminated by a palm grove just before the lowland allocated to the crop of rain-fed rice (Fig. 1). Sedentary Peulh farmers breed cattle and cultivate rice, pearl millet, maize and groundnut. The local cattle breed is N'Dama (*Bos taurus*). Adult females reach 200 kg of live weight and a wither height between 100 and 120 cm. Except for the rice fields, the cropland, i.e. crop fields interspersed with fallows, surrounds the households on the pediments.

During the rainy season (end of June–beginning of October), cattle herds are kept on rangeland and in forests by herdsman, away from the cropland. From early to mid-October, as pediments' crops are harvested, herds come back progressively in the cropland and in the fallow farmland on the pediments, where they are left to graze more or less freely during the day. However, animals are herded to avoid rice crop damage, as rice harvest occurs all December long. Besides, during the whole dry season, cattle spend nights grouped, but individually tied-up on a part of a field, on the pediments, the so-called night park. Thus, during that period from October to December, named hereafter early dry season (EDS), cattle graze first on the pediments, crop residues in the fields, as well as mature grass (called standing hay) in fallows, savannah and palm grove, as well as annual dicotyledons and grass in the fields and in the palm grove (Table 1). Then, in December, herds spend more and more time in the lowland, grazing harvested rice straw sometimes still drying (Fig. 1; Section 3.2). Millet, maize and sorghum fields contain cereal straw, but also leaves and a few remaining cobs. In the groundnut fields, sparse annual dicotyledons are present. In the palm grove, a dense vegetation of green grass (*Pennisetum pedicellatum*, *Digitaria horizontalis*, *Brachiaria mutica*, *Rottboellia* sp., *Cynodon* sp., *Paspalum* sp.) and leguminous species (*Stylosanthes* sp., *Alysicarpus* sp., *Calopogonium* sp.) is interspersed with standing hay (*Andropogon pseudapricus*, *Andropogon gayanus*, *P. pedicellatum*). In fallows and savannah, cattle graze standing hay and litter of ligneous materials (leaves or senescent fruits from *Prosopis africana* or *Adansonia digitata*) mixed with straw.

From the full rice harvest, in early January, cattle are left to graze on their own. This full free grazing period ends in late June, start of the cropping season. From January to March, named hereafter the mid-dry season (MDS), cattle graze mostly rice residues. Herds spend most of the time on the rice straw (Table 1). In the fallows and in the savannah, standing hay is still grazed. In the border of the palm grove and in the forest areas, herds consume fruits of *Daniellia oliveri*, pods of *P. africana*, flowers of *Bombax costatum*, and inflorescences of *Cola cordifolia*, mainly.

After mid-March, rice straw is almost fully consumed: it is the late dry season (LDS, March–June), the warmest period until the first rainfalls in June. Plant biomass is

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