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Gastrointestinal passage of Sahelian roughages in cattle, sheep and goats, and implications for livestock-mediated nutrient transfers

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Abstract

Green and dry pasture vegetation and millet crop residues are the main feed for domesticated ruminants across the West African Sahelian zone. Studying their gastrointestinal passage is important for modelling livestock-mediated nutrient flows in these agro-pastoral systems. Intake, passage, digestion and excretion were studied in 16 cattle, 16 sheep and 16 goats offered these feeds at levels corresponding to 0.8 and 1.3 times voluntary feed intake. Parameters of particle passage were derived from faecal excretion of a pulse-dose of short (1–2 mm) and long (>2 mm) particles labelled with Ytterbium, using age-dependent Gamma-2 single-compartment models.

Across the three species, mean retention time of particles in the mixing compartment (CMRT) varied between 39–50 and 54–66 h in green and dry pasture vegetation and between 66 and 88 h in millet leaves, and was always longer in cattle than in small ruminants ($P<0.05$). Particle passage through the mixing compartment (λ), particle half life (T_{50}) and total tract mean retention time (TMRT) were correlated to the dry matter digestibility and to the contents of nitrogen and neutral detergent fibre of the ingested diet, while particle size had no and feed intake only a weak influence on these parameters.

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The results suggest that seasonal and species-specific differences in gastrointestinal passage of feed particles should be taken into account when addressing the temporal aspects of livestock-mediated matter and nutrient flows across the agro-pastoral landscapes of the Sahel.

Keywords: Particle passage; Roughages; Cattle; Sheep; Goats; Nutrient transfer; Sahel

1. Introduction

In the Sahelian countries of West Africa, crop yields decline due to low rainfall and poor soil fertility. At the same time, the annual population increase of about 3% in the region (UNDP, 2003) calls for intensified food production. So far, the latter essentially relies on recycling of plant matter and livestock dung (Schlecht and Buerkert, 2004). Through the intake of organic matter and nutrients in one place and the subsequent faecal excretion of the indigestible fraction of the diet along with microbial biomass and endogenous substances in another place, livestock-mediated source–sink relationships between different fields, fallows and rangelands, watering and resting points are building up within the grazed area. When and where the indigestible fraction of a unit of feed is excreted is primarily influenced by its rate of passage through the gastrointestinal tract, and is modulated by the diurnal rhythms of grazing, water intake and resting and by decisions on pasturing time, grazing itineraries and nocturnal location of animals (Schlecht et al., 1998). To model the spatio-temporal flows of indigestible feed fractions, the rate of particle passage through the gastrointestinal tract must be assessed. Seasonal variations in quality and amount of feed ingested are considerable in Sahelian grazing systems (Schlecht et al., 1999; Fernandez-Rivera et al., 2005). It is expected that the gastrointestinal passage of indigestible feed particles and the resulting source–sink relationships between different land units are also affected by seasonality. Therefore, the present study aimed at determining compartment and total gastrointestinal passage of short and long particles of major Sahelian roughage feeds, namely green and dry pasture vegetation and pearl millet stover leaves, as affected by the level of intake of cattle, sheep and goats. The implications of the results for the conception of models for livestock-mediated nutrient flows are discussed.

2. Materials and methods

2.1. Site, forages and experiments

Studies were carried out at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), located 45 km southwest of Niger's capital Niamey. Rainfall occurs during 42 (S.D. 6.9) rainy days from May to September and averages 556 mm/a (S.D. 128.9; period 1990–1999); the average annual daily temperature is 29 °C (ICRISAT-Niamey, Meteorological Division).

Green pasture vegetation, mature dry pasture vegetation and pearl millet stover leaves were investigated in series of three experiments. The green herbaceous vegetation of range