Abstract Because small ruminants (<15 kg) have a high ratio of metabolic rate to fermentation capacity, they are expected to select and require low-fiber, nutrient-dense concentrate diets. However, recent studies suggest that small ruminants may not be as limited in their digestive capacity as previously thought. In this study, we examined harvesting, rumination, digestion, and passage of three diets (domestic figs *Ficus carica*, fresh alfalfa *Medicago sativa*, and Pacific willow leaves *Salix lasiandra*) ranging from 10 to 50% neutral detergent fiber content (NDF) in captive blue duikers (*Cephalophus monticola*, 4 kg). Harvesting and rumination rates were obtained by observing and videotaping animals on each diet, and digestibility and intake were determined by conducting total collection digestion trials. We estimated mean retention time of liquid and particulate digesta by administering Co-EDTA and forages labelled with YbNO₃ in a pulse dose and monitoring fecal output over 4 days. Duikers harvested and ruminated the fig diet faster than the alfalfa and willow diets. Likewise, they achieved higher dry matter, energy, NDF, and protein digestibility when eating figs, yet achieved a higher daily digestible energy intake on the fresh willow and alfalfa than on the figs by eating proportionately more of these forages. Duikers maintained a positive nitrogen balance on all diets, including figs, which contained only 6.3% crude protein. Mean retention time of cell wall in the duikers’ digestive tract declined with increasing NDF and cellulose content of the diet.Digestibility coefficients and mean retention times of these small ruminants were virtually equivalent to those measured for ruminants two orders of magnitude larger, suggesting that they are well adapted for a mixed diet.

Key words Blue duiker · Intake · Rumination · Digestibility · Mean retention time

Introduction

The ruminant digestive system is based on the principle of delay and fermentation of plant fiber (Cork 1994). The rumen delays plant fiber in the gut long enough for symbiotic microbes to ferment cellulose into energy-rich byproducts (i.e., short-chain fatty acids). The delaying mechanism is the ruminal-omasal orifice which restricts the size of food particles that can pass on to the enzymatic stomach and lower tract (Demment and Van Soest 1985). Food particles are reduced in size by rumination and by action of the microbial population, and retention of particles depends upon the rate at which this occurs (Van Soest 1994).

The ability of the ruminant system to meet energy requirements depends largely on the animal’s size. Fermentation rates are presumed equal across ruminants of different sizes and 10–20% of potential food energy is lost through fermentation (Björnhag 1994). Gut capacity in mammals scales with body mass¹, yet basal metabolic rate scales with body mass⁰.⁷⁵. Therefore, the high ratio of metabolic rate to fermentation capacity suggests that small ruminants (<15 kg) must obtain substantial energy from sources other than microbial fermentation of cellulose in the rumen, and are unable to meet their energetic needs on diets high in cellulose (Demment and Van Soest 1985). Other small herbivores have solved the problem of slow fermentation and rapid passage by gut modifications that allow them to digest cell contents directly in the enzymatic stomach and selectively retain only the more digestible fiber for fermentation. These adaptations avoid digestive constraints faced by ruminants by allowing rate of passage through the foregut to be determined by intake rather than breakdown of particles (Cork 1994). For example, other small foregut fermenters, such as three-toed sloths (*Bradypus tridactylus*), tree kangaroos (*Dendrolagus* spp.), and colobid pri-
During 1997–1999. The same three adult male (4–6 years old, 3.9–4.2 kg) blue duikers were used in all the trials with three forages: black mission figs (Ficus carica), fresh alfalfa (Medicago sativa), and Pacific willow leaves (Salix lasiandra). The duikers used in this study were of the subspecies (C. monticola bicolor) and were descended from duikers imported from Natal, South Africa, in 1977 and 1982. Although the forages used in the experiments are not necessarily similar to the vegetation and fruits eaten by free-ranging duikers in Africa, they were chosen because they varied in fiber, protein, and tannin content, and were readily available at the study location or could be purchased commercially.

Harvesting trials

To determine how fast duikers could harvest each of the diets at a feeding station (i.e., animals do not have to move their feet to crop the next bite), three replicate trials were conducted for each animal and diet. A small portion of each of the diets was weighed and offered to each animal. A sample of the fresh forage was weighed and dried at 100°C for 24 h to correct for dry matter content. For these trials, fresh, whole figs were placed on the ground; 25-cm stems of fresh, preflowering alfalfa were anchored to a mat on the ground; and stems containing fresh Pacific willow leaves were anchored to the side of the animal pen. We videorecorded the animal while it foraged for 2–4 min, consuming 8–80 bites. After the trial, orts were dried at 100°C for 24 h, weighed, and subtracted from the dry mass offered to obtain dry matter intake. By reviewing the videotape in slow motion, we counted all bites and chews taken while the animals foraged, and calculated the mean intake rate (g/min), bite size (g), chewing rate (chews/s), bite rate (bite/min), and chewing investment (chews/g) for each animal. Rate of harvest of digestible energy (kJ/min) was estimated as the product of dry matter intake rate, gross energy of diet, and dry matter digestibility. The time (min/day) required to harvest enough energy to meet their daily energy requirements was calculated as digestible energy intake divided by the digestible energy harvest rate.

Rumination trial

To determine the time and effort blue duikers spend ruminating different diets, duikers were fed exclusively on each diet. The diets were the same as used in the harvesting trials, except dried mission figs were used rather than fresh figs because they were easier to keep and obtain commercially. For each diet, we observed 48 consecutive hours of rumination. An observer recorded the total time each animal ruminated, the number of rumination bouts, the number of boluses per bout, and the number of chews per bolus. Rumination time per day, mean seconds per bolus, number of boluses per day, chews per second, and chews per bolus were calculated from these data.

Digestion trials

To compare energy, protein, and fiber digestibility and intake among the diets, we conducted 5-day total collection digestion trials with a 3-day pretrial period. We gradually introduced the animals to each diet over a 2-week period, and then housed them separately in digestion cages that allowed us to collect all urine, feces, and orts. Each digestion trial consisted of a single forage diet of dried figs, fresh alfalfa, or fresh willow leaves. A mineral block and water were available throughout the trials, and the animals were weighed before, during, and after the trials.

During the 5-day trials, the total daily portion of the diet was weighed and offered each morning at the same time. Feces and orts were collected each morning and weighed. Two aliquots of feces and orts produced and the diet offered were obtained. The first was dried at 100°C for 24 h to calculate the dry mass of diet consumed and feces produced. The second was frozen for subsequent nutritional analysis.