THE MICROBIAL POPULATION OF THE QUOKKA FORESTOMACH

S.K. Baker
CSIRO Division of Animal Production, Floreat Park, 6014
and University of Western Australia, Nedlands, 6009, Western Australia

Introduction

A ruminant-like digestive physiology in the quokka, *Setonix brachyurus* (Quoy and Gaimard) was first demonstrated by Moir et al. (1956), and since then many similarities have been drawn between the digestive physiologies of the forestomachs of other macropod marsupials and ruminants. The macropods can be grouped according to feeding habit and forestomach anatomy (Hume and Dellow, 1980) as the ruminants have been grouped according to similar attributes. In the forestomachs of the macropods and the ruminants if the digestive physiologies and the microbial populations are similar, despite differences in the patterns of digesta flow and mixing, then comparative studies are needed to establish the functional interrelationships between the microorganisms. Part of a study to compare the microbial populations along the quokka forestomach with the microbial population of the reticulo-rumen is reported here.

Materials and Methods

Samples of digesta were collected from the cul-de-sac (C), from two sites equidistant along the sacculated part of the forestomach (F_1 and F_2), and from the glandular region of the foregut near the pyloris (G) of a quokka fed fresh lucerne. The quokka was given an overdose of sodium thiamylal four hours after feeding, then the alimentary tract exposed and ligated at the pyloris. The digesta samples were diluted in formol saline, and the microorganisms (principally bacteria) were counted and classified according to cell size using a Coulter counter. The procedure has been described by Baker (1984).

Results

The forestomach of the quokka and the reticulo rumen present similar environments for microbial proliferation. Direct counts of bacteria and ciliate protozoa in the quokka (table 1; R.E. Hungate and R.J. Moir, personal communication; Hunton, 1982) are comparable with those from sheep fed similar diets. The predominant bacteria are Gram-negative rods and small cocci. Fewer morphological types of bacteria and protozoa are observed in the quokka forestomach than in the reticulo-rumen of sheep.

Classification according to size of the organisms in a community is a fundamental description of the structure of that community, and pyramids of numbers (or Eltonian pyramids) represent the structures of communities. A pyramid of numbers is characteristic of an ecosystem and can be a common denominator in comparisons of different communities. Baker (1984; 1985) represented the frequency distributions of rumen bacteria classified according to cell size by linear regression equations; comparison of the regression coefficients constitutes comparisons of the size structures of bacterial populations. She found that the Y-intercept, a, was strongly correlated with the direct count, and that the regression coefficient, b, was more sensitive to changes in the size structure of the population than was the direct count. For a range of dietary conditions the size structure of the rumen populations in sheep is unchanged and appears to be characteristic of a stable rumen population.

The size structures of the bacterial populations along the quokka forestomach are similar ($p < 0.05$) (table 1) and they resemble the size

TABLE 1. DIRECT COUNTS OF BACTERIA AND REGRESSION EQUATIONS TO DESCRIBE THE POPULATION SIZE STRUCTURE

Sampling site	Direct count ($\times 10^{10}$/ml)	Regression equation (r^2; RMS; d.f.)
Cul-de-sac (C)	2.96	$y = 9.06 - 3.16x$ (0.99; 0.02; 27)
Forestomach (F_1)	2.32	$y = 9.22 - 2.90x$ (0.99; 0.01; 27)
Forestomach (F_2)	2.58	$y = 9.35 - 2.69x$ (0.99; 0.01; 27)
Glandular stomach (G)	1.15	$y = 8.91 - 2.70x$ (0.99; 0.02; 27)

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structure of the rumen population in sheep fed oaten and lucerne hays ($p < 0.05$).

In the macropods the crude protein concentration is greatest in the cul-de-sac and is 1.2 times greater than the crude protein concentration of the diet (Dellow, 1979). This together with a high rate of volatile fatty acid production and high rates of disappearance of soluble sugars and urea-nitrogen there (Dellow, 1979) indicate that the microbial fermentative activity and microbial biomass are concentrated in the cul-de-sac. In the quokka and other macropods the number of protozoa, and therefore the contribution to the microbial biomass, is highest in the cul-de-sac and decreases along the forestomach (Dellow, 1979; Hunton, 1982). As well, the large bacteria represent a large proportion of the bacterial biomass (table 2) but numerically they represent a small proportion of the population (ca. 10^5/ml digesta). The small bacteria (0.5 to 1.0 μm in diameter) in the cul-de-sac constitute 32% of the biomass of the bacterial biomass. In animals basal energy metabolism varies inversely with body size, and the same allometry has been demonstrated in unicellular organisms (Hemmingson, 1960). By virtue of their small size, the population of small bacteria may contribute more to the high fermentative activity in the cul-de-sac than do the larger bacteria.

There are clear similarities in the size structures of the bacterial populations in the forestomach of the quokka and the reticulo-rumen of sheep. Eltonian pyramids reflect the trophic and energetic relationships within a community. If the size structure of the bacterial population reflects the trophic or functional structure of the forestomach ecosystems in ruminants and macropods, then the energy transactions that occur in these forestomach are similar.

TABLE 2. MICROBIAL BIOMASS AS A PROPORTION OF THE TOTAL FOR ORGANISMS 0.51 TO 16.3 μm IN DIAMETER

Size range (diameter, μm)	Sampling site (see table 1) C	F^1	F^2	G
0.51 – 1.27	0.32	0.26	0.15	0.18
1.28 – 3.21	0.24	0.24	0.27	0.23
3.22 – 6.44	0.19	0.21	0.27	0.19
6.45 16.3	0.25	0.28	0.32	0.41

(Key Words: Energy Transactions, Rumen Population)

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