A TRIBUTE TO BILL McCLYMONT

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Professor G L McClymont, during his long and distinguished career has made notable contributions to agricultural research and development, to agricultural education and extension and to overseas aid programmes. In later years he successfully applied the principles of ecology to the integration of the technological, economic and social factors involved in sustainable systems of agriculture. These comments, however, are concerned with Bill McClymont% perceptive and wide ranging research activities in animal science, and with his success in creating a research environment that over the years has proved extraordinarily productive.

Bill McClymont joined the Nutrition Research Laboratory at the Veterinary Research Station, Glenfield, in 1941 after graduating in Veterinary Science with First Class Honours and University Medal at the University of Sydney. At that time few veterinarians were involved with animal nutrition. Bill McClymont, however, quickly responded to the challenge posed by economically-important disorders in apparently well-fed livestock that failed to respond to conventional therapy. It is likely that his research at Glenfield on metabolic diseases such as ovine ketosis and the low milk fat syndrome contributed to his recognition that efficient animal production is dependent on a complex interaction between soil, pasture, climate, livestock and management. This found ultimate expression in his creation of the Faculty of Rural Science, with a unique undergraduate course in . agricultural science embracing these principles.

Bill McClymont began his research career in the decade that saw dramatic changes in our understanding of ruminant nutrition. The group at Cambridge led by Sir Joseph Barcroft, and which included A T Phillipson and S R Elsden, demonstrated that dietary carbohydrates are fermented in the rumen to short chain volatile fatty acids (VFA). These acids, of which acetate is quantitatively the most important, were shown to be absorbed from the rumen and to function as the major energy source for ruminants. Bill McClymont arrived in Cambridge to undertake his PhD studies at a time when these new and exciting aspects of ruminant metabolism were emerging. Two other Australians working for their doctorates in Cambridge at that time, R L Reid and I W McDonald, also took full advantage of this unique research environment, and went on to become internationally recognised authorities in the field of ruminant metabolism.

The recognition of acetate in sheep rumen contents and in sheep blood by Reid (1950a, 1950b) led McClymont (1951a) to examine the VFA in the blood and rumen contents. of cattle, and in the blood of other species. These studies were undertaken when the available methods for VFA analysis, based on liquid-gel chromatography, were cumbersome and time-consuming. Nevertheless, acetate was shown to account for more than 90% of the VFA in the blood of cattle, and significant amounts of acetate were detected in the blood of the rabbit, guinea pig, horse, and pig, and in human plasma. As in sheep, acetate was shown to be the major component of rumen VFA in cattle. The virtual absence

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of propionate in blood, in spite of earlier evidence of its uptake from the rumen, led McClymont (1951a) to the view that propionate is a major source of glucose in ruminants. The importance of this source of glucose became apparent when he showed (unpublished observations with R Scarisbrick) that less than 3 g/day of glucose was absorbed by a sheep. This finding that only small amounts of alimentary glucose become available to ruminant tissues preceded similar observations of Heald (1952), which are'frequently cited.

Recognition of the quantitative importance of acetate in ruminant metabolism inevitably led to interest in the role of this lipogenic substrate in milk fat synthesis. This subject was tackled in a typically direct manner by McClymont (1951b), who measured the uptake of acetate by the mammary glands of the lactating cow using the classical arterio-venous (AV) difference procedure, Much earlier work on the role of blood-borne substrates in milk synthesis using the AV difference procedure was vitiated by the use of venous blood in place of less accessible arterial blood (see Linzell, 1974), but Bill McClymont prepared his animals with carotid artery loops by adapting a procedure developed for goats (McClymont, 1950a). Although blood flow was not measured unequivocal evidence was obtained that substantial amounts of acetate are extracted from blood by the mammary gland, and that acetate uptake is linearly related to arterial level (McClymont, 1951b). At the time that these studies were in progress, ^{14}C labelled acetate became available for metabolic studes and Popjak et al (1951) demonstrated the incorporation of labelled acetate into short and medium chain milk fatty acids in the goat.

The application by Bill McClymont of AV difference measurements to the study of mammary gland metabolism foreshadowed the exploitation of this technique by J L Linzell and his colleagues a decade or so later. Much of current knowledge on the biosynthesis of milk protein, milk fat and lactose, and of mammary metabolism in relation to whole animal metabolism is based on a combination of AV difference and isotope dilution procedures (see Linzell and Annison, 1975).

One of the problems which attracted Bill McClymont% attention when he returned to Glenfield was ovine pregnancy toxaemia. This economically important syndrome, which is generally associated with chronic or acute undernutrition, has proved to be complex in its aetiology, and difficult to treat. In his research on pregnancy toxaemia, Bill McClymont was joined by B P Setchell, who subsequently achieved international recognition as a reproductive physiologist and is currently Professor of Animal Science at the Waite Institute, Adelaide. McClymont and Setchell (1955a,b; 1956a,b) in a series of studies with pregnant ewes showed that hypoglycemia was central to the development of the syndrome. Complete definitions of the conditions was not achieved, however, and indeed, even today some uncertainty exists concerning the primary cause of the impairment of the nervous system that characterises the disease (see Lindsay, 1985). The identification of ovine pregnancy toxaemia as a hypoglycemic encephalopathy led McClymont and Setchell (1956c) to examine the possible utilisation of acetate by the sheep brain. Their conclusion that acetate is not used by the brain has been confirmed by later studies.

Bill McClymont (with R Paxton) published a note in the Agricultural Gazette of NSW in October 1947 on the prevention of the depression in milk fat which may occur when dairy cattle graze on young oats. The need for supplementary *coarse* roughage was identified, and in a subsequent publication

(McClymont, 1950) the need to provide roughage when concentrates are fed was also recognised. The requirement of dairy' cattle for long roughage had been observed earlier (see Annison, 1985), but the causes of the low fat syndrome remained to be elucidated (McClymont, 1950).

Although Bill McClymont moved into other areas of research, the problem of the low milk fat syndrome stayed with him. A few years later, with brilliant intuition, he initiated a series of experiments which led to a radical change of current views on the causes of the syndrome. The prevailing opinion at that time was that reduced availability of acetate to the udder was the primary cause of the fat depression. This was not surprising, in view of the intense research activity in the 1950s on the role of acetate both as a major energy source for ruminants, and as a precursor of milk fat in ruminants (see Annison 1983). Bill McClymont, however, recognised that diets which depressed milk fat usually gave rise to enhanced ruminal production of propionate, a major glucose precursor. This led him to examine the effects of the intravenous infusion of glucose on milk fat composition in cows (Vallance and McClymont, 1959; McClymont and Vallance, 1962). Milk fat levels fell, and it was correctly hypothesised that the effect was mediated via increased insulin secretion. A great deal of subsequent work has confirmed these conclusions of Bill McClymont (see Annison, 1985).

Perusal of Bill McClymont's list of publications reveals his contributions to many areas of animal nutrition. While at Glenfield his work on poultry provided a sound nutritional basis for the developing Australian broiler industry. Many years later long term studies with B S Sathe, R B Cumming and later with A C Kondos, on the nutritional evaluation of meat meal, a major protein source, was of great benefit to the poultry industry (Sathe et al 1963; Sathe and McClymont, 1964, 1965a, 1965b, 1967, 1968; Kondos and McClymont, 1972). Meat meal today is a somewhat variable product but at the time when Bill McClymont, R B Cumming and B S Sathe began their studies, there were wide batch-to-batch variations in the 'level of bone in the meal, and in the extent of heat damage. Their studies provided key data for the formulation of poultry rations.

Carbon tetrachloride, widely used as an anthelmintic in the 1950s, occasionaly resulted in heavy stock losses. Bill McClymont with Alex Kondos, became interested in the problem of carbon tetrachloride poisoning, and their studies did much to establish conditions for the safe use of this hepatotoxin (Kondos et al, 1963; Kondos and McClymont, 1965, 1966 and 1967).

The appointment of Bill McClymont as Professor and Dean of Rural Science in 1955 inevitably reduced, his research output as an increasing proportion of his time was committed' to the creation of a unique undergraduate course in agricultural science. He recruited teaching staff with proven research skills, however, and his own research reputation with the animal industries ensured adequate financial support for many collaborative research projects. Limited space and facilities in the early years of the Faculty might have been expected to restrict research activity, but under the enthusiastic and inspiring leadership of Bill McClymont, research flourished and the high standards of scholarship which characterise the Faculty today were firmly established. For those of us fortunate enough to have been Bill McClymont% colleagues during those formative years, the prevailing, feeling was. that we were part of an exciting academic adventure. The success of that McClymont-led adventure is now common knowledge.

In the early 1960s Bill McClymont recognised that progress in solving many problems in nutrition, and in the area of metabolic diseases was severely handicapped by inadequate information on the intermediary metabolism of ruminants and non-ruminants. At that time metabolic intermediates labelled with radioisotopes became available, and Bill McClymont gave every encouragement and support to the use of this new tool in metabolic studies. Many colleagues and postgraduate students in his Department were involved in those early years, and new ground was broken when quantitative information was obtained on the turnover and contribution to oxidative metabolism of the major energy yielding nutrients in the sheep (Annison et al 1963). At a later date, facilities for the use of the stable isotope ^{15}N were introduced, and for the first time, quantitative data became available on nitrogen metabolism in the rumen (see Leng and Nolan, 1984). The sequence of research breakthroughs in ruminant metabolism which started in the 1960s has continued at breathtaking pace under the leadership of Professor R A Leng. Bill McClymont, and those of us who were were with him in the early years take great pride in the achievements of Ron Leng and his colleagues, who in consolidating the standards of excellence established by Bill McClymont have created one of the foremost internationally recognised centres for ruminant research.

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