Chapter 1

GENERAL INTRODUCTION

General introduction

Fresh or conserved forage from intensively managed grassland is widely used as a major feedstuff for high-production ruminants. However, high mineral nitrogen inputs in such production systems, together with the low level of efficiency of nitrogen utilisation by the animals, contributes to environmental pollution, a subject of substantial public and ecological concern (Tamminga and Verstegen, 1992; ten Bergeetal, 2002). Due to the rhizobial fixation of atmospheric nitrogen, mineral nitrogen fertilisation could be reduced or even eliminated, if fodder legume plants were grown in a mixture with grass. Up to 400 kg N ha^{-1} per year has been estimated as a potential value for nitrogen fixation from the atmosphere (Carlsson and Huss-Danell, 2003). Moreover, forage legumes are generally valued for their high feeding utility in ruminant nutrition (Sheldrick *et al*., 1995). These features make fodder legumes a valuable crop for organic farming; in particular, when the use of mineral fertiliser is limited and the requirement for high quality roughage is regarded to be at least as important as in conventional farming, since concentrates are usually preferably supplied at a low level.

Extensification of grassland management, in relation to fertilisation, also stimulates the growth of indigenous species of wild flowers in the swards. Botanically diverse grassland, which has been the subject of increasing interest in recent years for species conservation, has also been shown to increase the seasonal yield per area (Bullock *et al*., 2001; Minns et al., 2001; Isselstein, 2002; Sanderson *et al.,* 2004). Some forbs, i.e. non-leguminous dicotyledonous herbs, are rich in minerals and are palatable, thereby offering an attractive potential as feedstuffs for ruminants (Foster, 1988; Lopez *et al*., 1991; Wilman and Riely, 1993; Isselstein, 1994; García-Ciudad *et al*., 1997; Kuusela and Hytti, 2001). However, their chemical composition may vary widely and more information is required about their nutritive values.

Substantial proportions of grassland forage are conserved as silage and it has long been known that, because of a high buffer capacity and low sugar content, swards of intensively nitrogen-fertilised grass (O'Kiely and Muck, 1998) or mixtures of grass, legumes and forbs may produce inefficient fermentation in feed preservation (McDonald *et al.*, 1991). Antimicrobial secondary plant constituents particularly prevalent in legumes and forbs may also affect the fermentation process during ensiling (Woolford, 1984). Finally, silage composed of grass, legumes and forbs

will also have special effects on rumen microbes, ruminal fermentation being considered as the most important factor determining the feeding value of this group of fodder plants.

If more information was available about the nutritive value of forage from swards containing forbs, in particular, farmers would perhaps become less reluctant to integrate such plant species into their grassland, and this might even have a positive influence on the area of species-rich grassland, as well as that of non-fertilised grassland. Last, but not least, these aspects related to biodiversity and the environment are further arguments for studying the feeding value of products from grasslands managed in different ways. In the study reported here, mixtures of non-fertilised ryegrass and white clover, or mixtures of non-fertilised ryegrass, white clover and forbs, were compared with fertilised ryegrass. Dandelion (*Taraxacum officianle*) and ribwort (*Pantago lanceolata*) were studied, since these two plants - among others – are species which traditionally are not sown in extensively managed or natural grassland (Lopez *et al*., 1991; Kuusela and Hytti, 2001).

Objectives of the study

The investigations reported here were designed to analyse and characterise the nutritional potential of mixtures of non-fertilised ryegrass and white clover or mixtures of ryegrass, white clover and forbs (dandelion, ribwort) compared to intensively fertilised ryegrass for ruminants, using chemical, *in vitro*- and *in situ*-methods.

The specific objectives were:

- To assess the ruminal degradation characteristics of silages composed of intensively nitrogen-fertilised ryegrass, mixtures of non-fertilised ryegrass and white clover, or mixtures of non-fertilised ryegrass, white clover and forbs (dandelion, ribwort) at two different harvesting times, applying well-established chemical analysis, *in vitro* gas production and cellulase digestibility.
- To determine the *in situ* degradation characteristics of ryegrass, white clover, dandelion and ribwort.
- To determine the fermentation characteristics in an artificial rumen simulation system (RUSITEC) supplied with silage of either intensively nitrogen-fertilised ryegrass, or mixtures of non-fertilised ryegrass and white

clover, or non-fertilised ryegrass, white clover and forbs (dandelion, ribwort) harvested at two different harvesting times.

- To apply a ^{15}N-based tracer technique for the quantitative determination of microbial protein synthesis in the rumen simulation technique (RUSITEC) provided with fresh forage of either intensively nitrogen-fertilised ryegrass, or a mixture of non-fertilised ryegrass and white clover, or a mixture of non-fertilised ryegrass, white clover and forbs (dandelion, ribwort).

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Chapter 2

NUTRITIVE VALUE OF GRASSES, LEGUMES AND FORBS IN TEMPERATE CLIMATES: A REVIEW