II.3 Organic <u>PRO</u>duction of <u>S</u>teers and Use of <u>BIO</u>active Forages in Livestock

Acronym: PROSBIO

Date: 28 February 2000, revised 28 July 2000

1. Summary

Organic meat production in Denmark covers mainly beef and pork. The present market share of organic beef is only 2% and the supply of organic high quality beef is thus restricted despite a steadily growing number of organic dairy farms. Economic profitability is seen as a major constraining factor in using dairy breed calves in beef production. However, the interest in organic meat production is increasing and the need for reliable information on production parameters and strategies is evident. The objective of this project is to contribute to development of economically viable production systems for organic meat (beef and pork). Emphasis is on steer production that try to improve animal health and welfare, product quality and nature value of marginal areas by grazing. This may provide a scientific basis for decision support to organic beef producers and provide future guidelines for management of marginal areas in order to increase biodiversity. The investigations include the use of selected forages with a possible influence on health and meat quality. This approach to improvement of meat quality and to health promotion, particularly parasite control, is novel and may limit the unwanted use of medication. It is thus the intention of the project to find ways of improving the internal and external quality of organic produce.

2. Research group

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3. Introduction

Organic meat production in Denmark covers beef and pork and to a lesser extent broilers. Organic beef production is based primarily on animals from dairy farms but less than two out of ten bull calves born on organic farms are slaughtered as organic (Anonym, 1997; 1999a). Many bull calves are sold to conventional farms, and the supply of organic high quality beef is thus restricted despite a steadily growing number of organic dairy farms. The market share of beef is only 2% (Anonym, 1999b).

However, the interest in organic steer/bull production is increasing. A recent questionnaire among Danish organic farmers showed, that 40% of the dairy farmers have initiated beef production based on bull calves (B. Nielsen, unpublished). Steers are produced on the majority of these farms (60%). Organic farmers expressed a wish to view the production on their farm as a whole system where all parts are used appropriately. Steers are preferred over bulls because of their calm temperament and their ability to consume large amounts of forage and thus utilize natural pastures of marginal land. However, economic profitability is seen as a constraining factor. The variable costs of the production and relationship between grazing intensity, finishing strategy and market value of the final product are largely unknown factors (Tallowin, 1997), and the need for reliable information on production parameters is evident.

Maintenance of nature values is within the concept of organic farming (Anonym, 2000), and rearing of steers in organic production systems may contribute to improvement and conservation of biodiversity of marginal land and other natural areas by extensive grazing. Extensive areas often have been abandoned or improved agriculturally by conventional farmers due to the inherent low and variable productivity. However, maintenance of biodiversity of these semi-natural areas is totally dependent on extensive grazing and no usage of pesticides and fertilizer (Hald, 1998). Particularly in low-lying areas, extensive grazing in an organic farming system seems to be the optimal choice, considering the risk of contamination of the aqueous environment. In these soils with a high content of organic matter, a high mineralisation takes place (Nielsen & Debosz, 1994), and grassland farming is preferable to other types of cultivation where ploughing may result in a high degree of N-leaching. There is, however, a lack of knowledge about how grazing systems and different stocking rates influence plant biodiversity on these pastures.

Production problems such as low live weight gain or even periodic live weight losses may make grazing marginal land less attractive to the farmer (Park *et al.*, 1994). Grazing of marginal areas also requires intensified looking after by the caretaker to ensure optimal welfare, particularly concerning problems with increased endoparasitic infections (Thamsborg *et al.*, 1998). Therefore it is important to devise strategies that both secure production and welfare of the animals, and increase in nature values of the areas.

Parasitic infections in organic heifers are also highly prevalent on clover grass pastures, and may occassionally cause clinical disease (Vaarst & Thamsborg, 1994). It is most likely that intensive steer production will experience similar problems but a comparison of steers and heifers under similar conditions will be very useful. Several studies have documented that almost all age groups of pigs on organic farms have higher parasite loads than their conventional counterparts (Roepstorff *et al.*, 1992). Although most organic fatteners are moved in-door at weaning, infections acquired pre-weaning may affect health and welfare. Thus, there is a strong need for finding non-medical methods of keeping these infections at acceptable levels (Thamsborg *et al.*, 1999). Use of naturally occuring plants and bioactive crops, offered through grazing or after harvesting, that limit parasitic infections, or show any other beneficial effect, is a new approach to the improvement of animal health in these production systems.

Low to medium productive natural pastures potentially contain a large number of naturally occurring wild plant species. Many of the wild species in semi-natural meadows – in contrast to species of improved, high productive pastures - contain high amouts of secondary plant substances (Rychnovská *et al.* 1994) which may affect health and meat quality of the grazing animals. It is possible that a more diverse composition of the fodder from these marginal areas or from a multi-species flora on pasture in rotation may increase the meat quality and add a better flavour to the final products. If such a relationship exist, it will, together with possible beneficial effects on health, represent new scientific information and will be a highly valuable argument in the competition for consumers. At present, cultivation of bioactive crops in Denmark is not developed.

In this project we want to contribute to improvement of production systems of organic meat with main emphasis on beef and less on pig production. The focus will be on steers from organic dairy farms with the intention of making good use of this not fully used resource. The use of marginal areas for grazing will combine the need for forage with nature conservation, which at the same time is expected to improve environmental conditions in such areas. The effect of different bioactive forages on parasite infections as well as on meat quality and flavour will be evaluated in both ruminants and pigs. The investigations will thus consider animal health and welfare, the farmer's economy, quality of the products, and biodiversty of naturally occurring plant species on grasslands used in the production.

4. State of the art

4.1 Organic steer production

Production strategies
The literature on organic steer production is virtually non-existent, and making inferences from international literature on conventional production may be questionable due to the use of highly productive monocultured pastures, possible use of growth promoters and a high proportion of concentrate in conventional production. Consequently, detailed recordings of production parameters and description of management procedures on private organic farms with steer production are necessary to devise future production strategies. Key figures for the economic outcome of the production are valuable in herd management.

Grazing systems
An important question in organic steer production is the use of grazing system. As mentioned in the introduction a combination of extensive grazing with organic steers on marginal land and nature conservation is highly desirable but the use of more productive clover grass pastures within the crop rotation may be necessary to achieve acceptable weight gains or perhaps parasite free pastures. This balance will be interesting to examine. On low-lying, low-productive meadows preliminary results with set-stocked Holstein Friesian steers have shown daily weight gains of 500-800 g with large variations related to stocking rate and quality of the pasture. Also variation between years was considerable. Problems with destruction of vegetation and bite down of the sward at high stocking rates were observed. Gastrointestinal parasite infections were building up over the years reaching in some paddocks levels harmful to health and production (Thamsborg, 2000 in press). Similarly, clinical lungworm infections were observed. More investigations are needed to suggest appropriate grazing strategies for steers that overcome these problems e.g. through the use of rotational grazing. A pending project with steers grazing high productive clover grass pastures will support the activitites within this project. Several investigations have been performed with grazing heifers but studies of heifers and steers co-grazing are few. Establishing a relationship between heifers and steers with regard to e.g. herbage intake, liveweight gain and health under similar conditions may offer the option of extrapolating results from heifers. With regard to susceptibility to parasitic infections, indications are that bull calves are more susceptible to infections than heifers, and steers are somewhere in between (Thamsborg *et al.*, 1999).

Herbage intake and adaptation to grazing
Several issues in relation to steer production deserve further attention. Herbage intake in beef steers on perennial ryegrass has estimated by the chromium-oxide (Wright *et al.*, 1986; Wright *et al.*, 1987) but the herbage intake in dairy bred steers on clover grass pastures is largely unknown. Our preliminary results indicate that the herbage intake in Friesian steers at approx. 200 kg of liveweight, is 11% lower than requirements according to Danish national standards (Nielsen *et al.*, 2000 in press). Further estimations based on the alkane analysis will performed in the present project in order to quantify the utilization of forage under different grazing conditions (clover grass sward and natural pastures). The turn-out of calves often result in weight losses in the range from 3-14% of liveweight within one to two weeks (HRA, personal communication 2000;

Wright *et al.*, 1986; Yarrow *et al.*, 1996, Pedersen *et al.*, 2000 in press) and this check in growth may persist throughout the grazing season. Possible explanations may include changes in rumen fill (Balch & Line, 1957; Coleman *et al.*, 1995), indigestion or coccidia infections. Some data suggest that adaptation to pasture may reduce weight losses (Therkildsen *et al.*, 1995) but further studies are needed.

Meat quality
The market for organic beef in Denmark is still limited. The production of high quality meat may improve the market situation. Steers have an advantage in meat quality compared to bull calves due to a high degree of marbling resulting in tender and tastier meat (Andersen *et al.*, 1983; Ender, 1995). The content of other compounds in organic meat may also improve the quality. Experiments indicate that larger proportions of forage in the feed ration during the finishing period result in a high degree of polyunsaturated fatty acids (Dhiman *et al.*, 1999). A high level of polyunsaturated fatty acids in meat may be advantageous to human health due to a putative anti-carcinogenic effect (Knight & Death, 1997). On the other hand, the larger intake of ß-carotenoids under grazing conditions may accumulate in fat and result in yellowish discolouration, which is refused by the consumer (Yang *et al.*, 1992). Also, problems with off-flavour after forage based finishing rations have been demonstrated several times (Griebenow, 1997;Vestergaard *et al.*, 2000). The relationship between feedstuffs, feeding strategy and meat quality is not well understood, and particularly feeding of large amounts of grass and/or legumes in the finishing period needs further examination. The use of bioactive forages will be discussed later (section 4.5)

4.2 The influence of steers grazing on biodiversity and forage production of natural habitats

Biodiversity of semi-natural grasslands
Maintenance and restoration of species-rich semi-natural, low-lying grasslands is of great public interest in Denmark. However, as Tallowin (1997) in a review on the topic concluded '*good agricultural management does not necessarily also constituent good conservation management'* and '*lack of agronomic data for a wide range of semi-natural grassland communities is seen as a severe impedance to the development of integrated livestock systems which might effectively use the forages that they produce*'. The research group has in the last 3 years performed a comprehensive study with grazing steers to examine interactions between plant production, forage quality, development in plant species biodiversity and animal production. The steers grazed low-lying meadows at two grazing intensities with light animals (1st year steers) and more heavy animals (2nd year steers) in sites of high as well as low botanical diversity. The meadows had not received fertiliser or pesticides for ten years. Additional plots without grazing and plots with cutting for hay were included. Considering that the effect of grazing strategy on the sward is long-term, it is valuable to make use of this system already available and well described, in the present project.

To maintain a high species richness light animals at low grazing intensity are expected to be best suited. In accordance, the effect of grazing intensity on biodiversity in the above mentioned study was found to be dependent on the initial species richness: at high initial diversity in species, richness decreased at high grazing intensity with first-year-grazing steers (Hald 2000, in press). In contrast, gap formation in the grass sward - as documented by the trampling of heavy animals at high grazing intensity on these organic soils (low physical strength) - is expected to be important for the initial phase of restoration of species rich meadows as germination of seeds from the seed bank or from outside is promoted in the gaps due to lack of competition and increased temperature variation. Grazing as a means of nature conservation may thus be used to maintain already species rich pastures or to improve pastures of low initial botanical diversity.

Forage production
Forage production is influenced by choice of grazing system. Especially the low grazing intensity, often chosen in low-intensive grassland farming, will change the structure of the swards. The patchiness increases, which will lead to a reduction in animal production per hectare (Milne & Fisher, 1993). Also forage production from semi-natural areas is generally lower and of a lower quality compared to improved pastures within the crop rotation. The digestibility of the species found may range from very low to levels similar to *Lolium perenne* (Wilman &Riley, 1993; Nielsen & Søgaard, 2000 in press). On the other hand, the species diversity

also forms basis for a wide variation in chemical composition of herbage which extends to differences in trace elements and complex hydrocarbons. There are many secondary metabolites present in these plants which may affect animal health. Some of the wild species found on permanent pastures belong to families that have been used to treat human helminths, e.g. Urtica (nettle), Rumex (sorrel) and Ranunculus (buttercup). It is known that plant chemistry can vary between species, at different growth stages, and in response to growth conditions (Iason *et al.*, 1995; Hartmann 1996). Therefore it is important that samples examined for secondary metabolites are collected under well described conditions.

4.3 Bioactive forages: plants with secondary metabolites

Role of secondary metabolites in forage crops
Secondary metabolites are found in a large range of forage crops. The compounds are formed from side reactions of primary metabolites. Secondary metabolites are not essential to primary metabolism, but some of them may function as guards against consumption by herbivores and consequently be essential in plant survival (Burns and Barnes, 1985; Kakes *et al.*, 1991). Modes of action include:

- Anti-nutrients, sequestering proteins or vitamins in forms that are made unavailable to the digestive systems of insects and other herbivores.
- Feeding deterrents, imparting a distinctive and unpleasant taste to the plant. Coumarins and sesquiterpene lactones, for example, are bitter.
- Physiological toxins, imparting some or the other form of damage to the herbivore.

Secondary metabolites thus encompass a very large number of compounds that are often associated with reduced herbage intake and performance by animals ingesting the compounds (Burns and Barnes, 1985). The toxic effect on physiological functions will depend on the ability of the animal to degrade or excrete the substance (Kakes *et al.*, 1991). Of course, the herbivores have evolved corresponding mechanisms to evade or even exploit these same compounds. One of the forms of exploitation is to take over the plant metabolites and use them to defend the herbivore, once the herbivore has become resistant to the toxic effects of the compounds in question. The most extreme forms of this are the active accumulation of plant toxins seen in some insects, e.g. monarch butterflies. Examples of secondary metabolites include polymeric phenolic tannins, cyanogenic glucosides, alkaloids, sesquiterpene lactones, and saponins.

Beneficial effects of bioactive compounds in animals
Although many secondary metabolites are thus considered as antinutrients and thus unwanted in relation to feeding of livestock, there are examples of beneficial effects of secondary metabolites, or other bioactive compounds in animal production (see 4.4-4.5). In this project we base our investigations on previous studies that implicate plant species containing proanthocyanidins, also called condensed tannins (CT) and the degradation resistant carbohydrate inulin as having functions on parasite populations and meat quality, respectively. Secondly, we screen a number of other plants for presence of possible anthelmintic substances.

The use of specific plants to control parasites is well known in human medicine. In many cases specific biologically active secondary metabolites have been identified but the mode of action is largely unknown. The chemical composition of plant material changes significantly during passage of the first parts of the digestive system. Some reactive compounds will be degraded to inactive substances, while others will be liberated from inactive forms, this is in particular relevant for glycosides. We will therefore subject the plant material to the same enzymes and incubation periods as encountered during digestion, the composition of the extract can be made to mimic as closely as possible the *in vivo* situation. To the best of our knowledge, this is a novel approach to the study of plant-derived anthelmintics.

Plant growth and production of secondary metabolites
The availability of relevant plants capable of growing in our climate and the agronomic conditions for optimal production of secondary metabolites are of major importance for the usefulness of this concept. Secondary metabolism is both genetically and environmentally controlled (Kakes *et al.*, 1991). Tannin may increase in concentration at high temperatures and short daylengths as a result of advanced maturity (Li *et al.*,

1993). Ehlke and LeGare (1993) reported that extended periods of high temperatures resulted in reduced tannin production of birdsfoot trefoil (*Lotus corniculatus*) because the plants were under nutritional stress. Forage species adapted to growth in Scandinavia generally do not contain high concentrations of tannin. One reason may be that plant breeders consciously have selected against tannin, but also that species do not require the same degree of defense against pests as in warmer regions of the world. Relatively little information exists regarding the responses of grazing management on production of secondary metabolites. However, management that results in rapid regrowth of crops will reduce the synthesis of secondary metabolites, since it will diminish the benefit for the plant of investments in defence mechanisms (de Jong 1995). This will increase the palatability of the herbage. The challenge we face in this project is consequently to identify suitable species, cultivars and management practices that ensure an extended growth and sufficient production of CT, inulin and other possible anthelmintic secondary metabolites.

Among typical forage crops grown in warmer regions than Scandinavia, CT in big trefoil (*Lotus uliginosus Schkuhr;* often (incorrectly) referred as *Lotus pedunculatus*) and lespedeza (*Lespedeza cuneata*) has been stated to range from 76 to 90 g kg^{-1} DM (Barry, 1985). Other species that contain less CT include sulla (*Hedysarum coronarium*), birdsfoot trefoil and sainfoin (*Onobrychis viciifolia*) that range from 25-84 g kg^{-1} DM CT (Terill *et al.*, 1992; Hoskin *et al.*, 1999; Poli *et al.*, 1998; Donnelly and Anthony, 1973). Chicory contains very little CT (<3 g kg^{-1} DM). Birdsfoot trefoil, sainfoin, chicory and Jerusalem artichoke grow well under Danish conditions but are difficult to establish. Attempts by researchers in the group to grow lespedeza have been unsuccessful, and big trefoil and sulla only have been grown with various degree of success. Most of the experience growing these crops may be found in literature that is 50 to 100 years old. While it is necessary to consider recommendations from those days, it is equally important to find agricultural practices that are suitable in present Danish organic production.

4.4 Effects of bioactive plants on animal health with emphasis on parasitism in ruminants and pigs

Helminth infections in organic farming

Helminth infections are more prevalent (more species, higher worm burdens) in organic ruminants and pigs than in conventionally reared animals. The transmission of helminths depend on environmental factors. Outdoor conditions are in general favourable for the development and survival of the infective stages. In organic production and, starting from last year (1999), in conventional farms, it is not allowed to treat livestock prophylactically with commercially available anthelmintics. Therefore, there is presently in both production systems a strong need for development of means of controlling (or balancing) infections non-medically which, in brief, include grazing management and provision of sufficient feed in association with building up of immunity (Thamsborg *et al.*, 1999).

Studies on the interactions between nutrition and helminth infections in ruminants are numerous. In ruminants, it is well known that the level of protein in the feed affects both regulation and pathogenicity of infections, probably by compensating for the nematode induced protein loss and enhancing immunity. In pigs, high levels of insoluble dietary fibres have resulted in higher levels of infection with *Oesophagostomum* spp. compared to diets of similar protein and energy levels but rich in soluble fibres (inulin), digestible carbohydrates and proteins (Petkevcius *et al.*, 1999). These findings may have important implications for livestock under organic farming conditions.

Anthelmintic effects of tanniferous forages

Recent data suggest that also crops or forages with secondary metabolites may affect the outcome of parasitic infections. Certain leguminous crops with a high concentration of CT seem to affect nematode infections or improve performance of parasitised lambs. Worm burdens in lambs have been reduced by up to 50% depending on species by feeding sulla or big trefoil (Niezen *et al.*, 1995). Concentrations of CT of less than 10% of dietary DM are believed to protect plant protein against ruminal degradation thus increasing the protein availability in the small intestine and improving the animals' protein supply (Waghorn *et al.*, 1997). However, it has been difficult to relate anti-parasitic effects to the actual amounts of CT (e.g. Niezen *et al.*, 1998). A complicating factor is that CT is a poorly defined group of compounds (basically polymers capable of covalently binding protein) making standardized determinations in plant material difficult. The possible mode of action is unknown. Besides the concept of better protein nutrition and thus enhanced immunity, a direct anthelmintic effect has been suggested in a recent study using quebracho, a CT extract as a single high dose with a favourable result (Athanasidou *et al.*, 1999). Our group have demonstrated the capacity of purified CT from Danish legumes to kill nematode larvae *in vitro* (Kahiya *et al.*, 1999).

Possible use of plants with anthelmintic properties
In this project the planned *in vitro* screening of extracts of different plants for anthelmintic activity will reveal presence of plant metabolites with direct effects on nematodes, similar to synthetic anthelminthic drugs. The traditional herbal treatments used against human (or animal) intestinal parasites comprise several plant species with high contents of known direct nematocides e.g. santonin from species of the genera *Santolina* and *Artemisia* (wormwood). These plants will be effective for short-term use e.g. short term stay in a "deworming" paddock before a pasture change or as a curative treatment. If the mechanism is indirect e.g. affecting the host's nutritional balance, the bioactive crops can be used continuously but must comprise a substantial proportion of the feed depending on plant species. These crops can be mixed with grass and clover in larger grazing areas or in pure stands for rotational grazing. Interestingly enough mixtures of herbs and grasses are common practice in biodynamic farming.

The concept of using pasture species (or naturally occuring herbs) with a possible effect on helminth infections in grazing management is promising and the possibilities seems far from exhausted (cf. Danø & Bøgh, 1999 and Waller *et al*., 2000 for botanical dewormers). Organic farming is more likely to integrate bioactive crops than conventional farming. Crops that can be established locally and used as part of the normal feeding regime are most likely to be acceptable to organic farmers. The frequent use of caraway and parsley on organic farms have already been demonstrated (Smidt, 1997), and documentation of beneficial effects is warranted.

4.5 Effects of bioactive plants on meat and eating quality in ruminants and pigs

Quality of organic meat
Data on meat and eating quality in ruminants and pigs fed organically produced roughage and concentrate is scarce. A market survey comparing organic and conventional pork showed significant differences in eating quality and composition of fatty acids (Claudi-Magnussen, 1999). Reasons for these differences, both positive and negative, in meat and eating quality are not known. However, it is likely that the composition of the feed for pigs in organic pig production including roughage play a major role. An experimental study has indicated that tenderness of pork decreased when concentrate was restricted and by that intake of roughage increased (clover-grass and clover-grass silage) (Danielsen *et al.*, 1999 & 2000). Researchers in our group have recently initiated a more comprehensive feeding trial with silage of clover-grass and barley-pea to compare meat and eating quality of organic and conventional pork (Hansen *et al.*, 1999a).

Chicory and related species: bioactivity
Chicory (*Cichorium intybus*) and Jerusalem artichoke (*Helianthus tuberosus*) contain substances that may positively affect meat and eating quality in pigs and steers and have for that reason been selected for initial trials in this project.

The hypothesis of a direct effect of chicory on the taste of pork is based on presence of sesquiterpene lactones (bitter compounds; primarily in the roots), bitter coumarins, tannins (with astringent taste) that primarily are present in the leaves, and inulin. Sesquiterpene lactones or coumarins may be responsible for an anthelmintic effect in ruminants (Hoskins *et al.*, 1999; Knight *et al.*, 1996; Niezen *et al.*, 1993; Scales *et al.*, 1995). Feeding of chicory leaves to ruminants up to a certain level may positively affect meat and eating quality (Barry, 1998; Choi *et al.*, 1998; Moio *et al.*, 1996). Cows are capable of consuming large amounts of chicory, but excessive amounts (above 25% on DM basis) will give a bitter taste in milk. Chicory roots as well as Jerusalem artichoke tubers contain the fructose polysaccharide inulin, which is indigestible by monogastric animals such as swine. Inulin reduces glucose uptake and thus glycogen accumulation and functions as a soluble dietary fiber. It also functions as a probiotic in pigs (Tungland, 1998) due to fermentation in caecum and colon, stimulating the growth of beneficial bacteria such as *Bifidobacteria* and *Lactobacillus*. This bacterial growth may influence the sensory (eating) quality of the meat by reducing - among other things - the skatole production in caecum and colon and by that reducing the boar taint (skatole in backfat) problem in male (and female) pigs (Claus et al., 1994; Jensen et al., 1997). Inulin appears to positively influence the water holding capacity and colour in pig meat (Rosenvold et al., 1999 & 2000) and the sensory (eating) quality of meat (Hansen *et al*., 1999b & 2000), probably through the hypoglycaemic and probiotic effect. However, a direct effect of sesquiterpene lactones and bitter coumarins is also likely.

Sensory aspects are of utmost importance to the eating quality of meat. To gain information on sensory properties such as colour, flavour and texture a methology referred to as sensory profiling may be utilised. This is a method by which a panel of sensory judges develops and applies a vocabulary to describe perceived sensory characteristics in a sample type. This sensory quality profile can then be related to the various treatments, such as the use of different bioactive crops for pigs or different finishing strategies for steers, as proposed in the present study.

Possible use of chicory and related species
An interesting aspect of chicory roots as well as Jerusalem artichoke tubers is that they may be beneficial as food and rooting source for outdoor organic slaughter pigs, as the roots and tubers fulfil the natural rooting and eating behaviour for pigs. Roots from chicory and Jerusalem artichoke fed in large amounts to pigs for shorter periods before slaughter may reduce the glycogen concentration in the meat and may increase meat colour, pH and the water holding capacity in pork (Rosenvold *et al.*, 1999 & 2000). As mentioned earlier, feeding of high levels of soluble, ingestible polysaccharides like inulin may also lead to lower worm burdens. In addition to the possible effects on animal health and meat quality, chicory is also likely to be particularly attractive as admixture in clover grass fields in an organic crop rotation. Chicory roots grow approx. twice as fast as those of grasses or clover. They will retrieve nutrients from soil layers that are not accessible to grass roots and thus provide important reduction in leaching losses, in particular late in the grazing season, when the problem is most pronounced (K. Thorup-Kristensen, personal communication 2000).

On this background, the focus in the present project will be on bioactive plants such as chicory and Jerusalem artichoke, which contain bioactive components such as inulin and sesquiterpene lactones and might have potential as organic forage crops

5. Objectives and expected achievements

The overall objective is to develop and document economically viable production systems for organic meat (beef and pork) with emphasis on steer production that try to improve animal health and welfare, product quality and the natural value of marginal areas by grazing. Furthermore, bioactive forages with a possible influence on health and meat quality will be investigated. Specific goals:

1 To describe and develop steer production on organic farms with focus on pasture based production, particularly grazing strategies
2 To evaluate the effect of different management strategies on production, and health and welfare of organic steers.
3 To compare production, parasitism and herbage intake in steers and heifers grazing marginal areas at different stocking rate or grazing systems.
4 To examine the interaction of grazing, forage production, and development in biodiversity in marginal areas of different initial richness of species.
5 To investigate the use of bioactive forages and products for improvement of health with particular reference to parasitic infections.
6 To improve meat and eating quality in relation to fattening strategies and bioactive forages.

The investigations related to steer production will provide a scientific basis for guidelines to organic beef production and will support organic farmers in making decisions regarding production strategies in their own enterprises. The perspective of having bioactive plants helping in control of parasitic infections and/or improving meat quality and flavour are prosperous. It may limit the unwanted use of medication and prolonged withdrawal times are avoided. Also the combination of steer production with improvements and conservation of biodiversity of marginal land in low-lying areas seems very beneficial for nature conservation as well as environment. All of these different aspects may improve economy of organic steer production or will help justify the higher prices of organic products and improve the image of organic farming systems as being special compared to conventional farming systems. Nevertheless, concepts and ideas developed in the present study regarding use of bioactive forages will be equally applicable in conventional farming.

6. Description of workpackages including methods

Table 1: Workpackage list

Work-package No	Work package title	Responsible participant	Budget	Start	End	Deliverable No
WP1	On-farm description and analysis of production and management strategies for steers	SMT	411,000	4/2000	2/2003	D19, D20, D21, D22, D23
WP2	Production strategies for steers on clover grass pastures	SMT	94,000	4/2000	2/2003	D13, D24
WP3	Grazing systems for steers on marginal land	TK	1,997,000	4/2000	12/2003	D15, D29, D30
WP4	Influence of different grazing strategies on biodiversity on marginal land	ABH	810,000	4/2000	12/2002	D2, D15, D18, D27, D28
WP5	Preparation of extracts for estimation of direct anthelmintic effect of plant species	KB	376,000	8/2000	12/2003	D1, D5, D6, D10
WP6	Influence of bioactive forages on animal health with emphasis on parasitic infections	SMT	1,242,000	4/2000	6/2004	D7, D14, D16, D35, D37
WP7	Test and large scale cultivation of bioactive forages	CO	376,000	4/2000	6/2004	D8, D9, D31
WP8	Influence of bioactive forages on meat and eating quality	LLH	1,264,000	1/2001	6/2004	D17, D34, D36

Table 2: Description of workpackages

WP1: On-farm description and analysis of production and management strategies for steers

Workpackage number:	1		
Start date or starting event:	4/2000		
Responsible person:	SMT		
Contributing persons:	TK	BN	
Person-months, Scientific:	0	Technical:	7

Objectives

- To describe and analyze feeding regimes, management procedures, housing facilities, animal production and welfare in steer production on organic farms
- To model the economical consequences of different productions strategies
- To evaluate the effect of different management strategies in factorial designs

Description of work

1.1 Steer production on 6 farms will be described by recordings of production factors such as feeding regimes, grazing management, housing facilities, finishing strategies, and production economy. Focus will also be on welfare of steers through monthly recordings of body condition, housing environment, and climatic conditions in the winter and summer period based on the TGI 200-system (Sundrum *et al.*, 1994). Production strategies are evaluated economically by models based on Markov decision processes (Makulska & Kristensen, 1999)(**task 1**).

1.2 Different feeding regimes in the winter period will be examined by estimating daily gain and condition scoring of steers fed: 1. Whole grain silage vs. clover grass silage or other forage; 2. concentrate vs. forage at iso-energetic levels of intake (**task 2**).

1.3 Different grazing strategies e.g. with or without concentrate supplementation are investigated to improve welfare and daily gain in calves. Different methods of adaptation of steers to grazing in order to minimize problems often seen around turn-out will be evaluated (**task 3**).

Deliverables

D19 and D20: Reports
D21, D22, and D23: International papers

Milestones

M1: Comparison of grazing strategies for steers and calves (12/2000+12/2001)
M2: Comparison of winter feeding strategies in steer production (7/2001+7/2002)
M3: Evaluation of models of welfare and production strategies (6/2002)

WP2: Production strategies for steers on clover grass pastures

Workpackage number:	2		
Start date or starting event:	4/2000		
Responsible person:	SMT		
Contributing persons:	TK	BN	HRA
Person-months, Scientific:	0	Technical:	½

Objectives

- To determine the actual feed intake of dairy breed steers on pasture
- To describe the relationship between conformation at slaughter of fat layer scoring and body condition with feed intake during the finishing period of steers

Description of work

2.1 Herbage intake will be measured by alkane analysis (Dove & Mayes, 1991). The intake of dairy breed Jersey steers will be compared. The intake of steers fed at different energy levels in the period before grazing will be compared. Repeated rectal faecal samples and herbage samples are taken in the experimental period of 8 days. Herbage and pooled faecal samples are then analysed for alkanes by means of gaschromatography (**task 4**).

2.2 Body condition scores, live weight, body size measurements and are recorded regularly. At slaughter, conformation is noted, and fat layer scoring by ultrasound is recorded, and a model is developed to use these measurements for management of feeding strategies and to determine optimal time of slaughter. (**task 5**).

Deliverables

D13 and D24: International papers

Milestones

M4: Estimation of feed intake by steers on clover grass pasture (9/2000)
M5: Development of a model for using body condition score as a management tool in steer production (6/2002)

WP3: Grazing systems for steers on marginal land

Workpackage number:	3			
Start date or starting event:	4/2000			
Responsible person:	HRA			
Contributing persons:	TK	SMT	BN	LLH
Person-months, Scientific:	13	Technical:	14	

Objectives

- To compare the production, feed intake and health of steers and heifers being co-grazed on marginal land
- To investigate the influence of a rotational versus a continuous grazing system on utilization of potential sward production, performance and health of steers on marginal low-lying land
- To investigate the influence of different finishing strategies, including bioactive forages, on composition of muscular fatty acids

Description of work

3.1 First-year-grazing steers and heifers will graze wet meadow pastures in 2 consecutive seasons (2000 and 2001). In 2000, the animals are kept at two stocking rates, whereas the animals in 2001 are subjected to two different grazing strategies (rotational versus continuous). All animals are weighed and examined clinically every month, and sward height and rejected grass are measured on paddock scale. Blood and faecal samples and herbage samples are collected regularly and examined to assess parasite infections and for relevant serological analysis (**task 6**).

3.2 Estimation and comparison of herbage intake by the steers and heifers in 2001 using the alkane method (cf. task 2.1) (**task 7**).

3.3 The first-year-grazing steers turned out in 2001 will continue for a second grazing season in 2002 before the final fattening period. The animals are subjected to two different grazing strategies (rotational versus continuous) in both seasons. In the fattening period different proportions of concentrate and roughage are used, supplemented with a bioactive forage (produced in task 7.4). All animals are weighed and sward height and bush grass are measured every month. Body condition score and body size measurements are registered regularly during the fattening period (**task 8**).

3.4 At slaughter of steers in 2002/2003, samples of meat will be collected from the carcasses and analysed for content and composition of fatty acids in order to compare different finishing strategies and effect of bioactive forages (meat and sensory quality: cf. task 8.2 (**task 9**).

Deliverables

D15 and D29: International papers
D30: Popular paper (in Danish)

Milestones

M6: Comparison of herbage intake in co-grazed steers and heifers (8/2001)
(closely linked to M2.1: Estimation of feed intake by steers on clover pasture 9/2000)
M7: Comparison of performance of 1-year grazing steers and heifers (12/2001)
M8: Evaluation of the effect of different grazing strategies on production and health of steers (3/2003)
M9: Establishment of the relationship between finishing strategy and fatty acids in meat (5/2003)
(evaluation of meat quality in general – cf. task 8.2)

WP4: Influence of different grazing strategies on biodiversity, forage quality and content of bioactive plants on marginal land

Workpackage number:	4		
Start date or starting event:	4/2000		
Responsable person:	ABH		
Contributing persons:	LN		
Person-months, Scientific:	10.5	Technical:	6.6

Objectives

- To investigate the influence of a rotational versus a continuous grazing system at low grazing intensity on sward structure, sward production and quality in relation to botanical composition on dry matter basis.
- To investigate the influence of different grazing regimes on the dynamics of biodiversity (high vs. low intensity with 1. year steers/heifers; rotational vs. a continuous grazing system with 1. year steers/heifers at low grazing intensity following the destruction of the sod by 2. year steers, i.e. gap formation)
- To evaluate the content of bioactive plants in the swards with different management strategies

Description of work

4.1 Sward production and herbage quality are examined 4 times during the season in rotational and continuous grazing system (**task 10**).

4.2 The effect of grazing heterogenity of the area is described by recording of sward structure in fixed lines across the paddocks 3-6 times during the grazing season, recording species in areas with high, medium and low sward height to evaluate grazing preferences. Sward structure will further be described by sward height measurements together with WP3 (frequency measurements) (**task 11**).

4.3 Biodiversity dynamics are measured with the same method used in previous years on the same location. In mid-summer the presence of species in the central 10x10m part of the grazed plots and reference plots (abandoned or cut twice a year for hay) is analysed at five permanently located sites by four concentric Raunkiær circles: ($0.001m^2$, $0.01m^2$, $0.1m^2$ +$1m^2$). Generative species are recorded separately (**task 12**).

4.4 The inventory done in 1997 and 1999 (in another project) at paddock scale to investigate changes in species occurrence on a larger scale will be repeated in 2001 (**task 13**).

4.5 The content of bioactive plants is evaluated in the swards subjected to different management strategies, the above mentioned grazing strategies versus cutting. In addition, naturally occurring plant species in the experimental marginal area are gathered for extracts (cf. task 16) (**task 14**).

Deliverables

D2: Deliver different plant species from marginal land to be examined in task 15
D15, D27 and D28: International papers/abstract
D18 : Popular paper in Danish

Milestones

M10: Evaluation of sward structure dynamics (11/2001)
M11: Evaluate the content of bioactive plants in the swards with different botanical composition (12/2001)
M12: Evaluation of bioactive plants, forage production and quality in relation to grazing strategy (12/2001 + 12/2002)
M13: The dynamics in biodiversity are analysed (3/2002+12/2002)

WP5: Preparation of extracts for estimation of direct anthelminthic effect of plant species

Workpackage number:		5		
Start date or starting event:		4/2000		
Responsible person:		KB		
Contributing persons:				
Person-months,	Scientific:	3.3	Technical:	4.2

Objectives

- To prepare extracts of relevant plant species, which correspond optimally with the subset of the plant constituents that will be present in the upper gut after ingestion.

Description of work

5.1 Development of controlled degradation procedure. Plant material of approx. 20 species (cultivated in WP 6+7 and wild collected in WP4) will be extracted under conditions mimicking the processes taking place during ingestion and subsequent passage through the gut. Extracts will be made by grinding fresh plant material in an aqueous enzyme solution corresponding to saliva, adding acid and enzymes to mimic the digestive processes of the stomach, and after incubation neutralise the acid and incubate again with enzymes corresponding to the upper gut. Primarily enzymes and pH regimes relevant for all herbivores will be used, but if the resources permit a simulation of specific ruminant processes will also be attempted. The first extracts to be made will be from species selected to enable evaluation of the *in vitro* testing for anthelmintic effects: white clover (cultivated) as a negative control, tansy (*Tanacetum vulgare* L.) (wild) with a proven nematocidal effect as a positive control, and chicory (cultivated or wild) as presumably intermediately effective (**task 15**).

5.2 For one or two species loss of selected secondary metabolites, including estimated content of condensed tannin, will be evaluated at each step of the gut mimetic procedure. The choice of compounds to be measured will depend on the effects found in the in vitro assays and on the availability of methods for analysis (developed in other projects). Examples of candidate compounds are chicoric acid and lactupicrin, both from chicory (**task 16**).

5.3 Analyses of total amounts of inulin (HPLC of extract before and after hydrolysis) and tannin (intensity of vanillin colour reaction) in material produced in WP6+7 or from pasture samples collected in WP4 (approx. 50 analyses of each, exact numbers will depend on detailed planning) (**task 17**).

Deliverables

D1: Determinations of inulin and condensed tannin concentrations in forages
D5: Report
D6: Extracts of cultivated plants
D10: Extracts of wild plants
D14: International paper (in collaboration with WP6)

Milestones

M14: Development of a gut-mimetic system for extraction of bioactive secondary metabolites (10/2000)
M15: Extracts of cultivated and wild plant species for testing of anthelminthic activity (12/2000+10/2001)

WP6: Influence of bioactive forages on animal health with emphasis on parasitic infections

Workpackage number:		6		
Start date or starting event:		4/2000		
Responsible person:		SMT		
Contributing persons:		ARO		
Person-months:	Scientific:	15	Technical:	13

Objectives

- *In vitro* testing of anthelmintic effect of plants against bovine and porcine nematodes
- *In vivo* testing of anthelmintic effects of plants in infected lambs and pigs

Description of work

6.1 *In vitro* studies I. Plant extracts (from WP5) from selected plants will be tested for anthelminthic activity against free-living stages of common bovine (*Ostertagia ostertagi* and *Cooperia onchophora*) and porcine (*Oesophagostomum dentatum*) helminths. A modified Larval Development Assay (LDA)(Hubert & Kerbouef 1992) will be developed to test the larvicidal effect of increasing concentrations of the extracted substances in microtiter plates and estimating the LD50 (**task 18**).

6.2 *In vivo* studies in ruminants (sheep). Lambs will be experimentally infected with gastrointestinal nematodes while grazing plots of selected forages, including initially *Lotus* spp., sainfoin and chicory. Controls will graze white clover-grass swards. In addition to plots already established at KVL, new areas will be established at DIAS. Faecal egg counts, worm burdens, animals' clinical status, performance and feeding behaviour will be studied and also the tolerance of plants to grazing. Similar trials (or in-door trials) will be performed with any plants found relevant in the *in vitro* assays (**task 19**).

6.3 *In vivo* studies in monogastrics (pigs). Plants giving the most promising results in the *in vitro* assays will be selected for *in vivo* trials in pigs. Pigs infected with patent infections of *O.dentatum* and *A.suum* will be given 2 or 3 levels of the active plant/forage for 3-7 days. Parasite egg output will be followed and the intestinal worm burdens will be compared with non-treated controls. (**task 20**).

6.4 Studies on antiparasitic effects of chicory (or other relevant species) in pigs after testing of palatability. Pigs infected with *O.dentatum* and *A.suum* will be used under controlled, in-door conditions. Clinical status and performance of the animals are also studied. These studies will be performed in conjunction with WP8 (meat and eating quality) using forage supplied by WP7 (**task 21**).

Deliverables

D7: I*n vitro* assays for anthelmintic activity of plant extracts
D14, D16, and D37: International papers
D35: Identification of plants/forages with short or long term anthelmintic effects

Milestones

M16: Development of *in vitro* methods for evaluating anthelmintic activity (12/2000)
M17: Comparison of *in vitro* anthelmintic activities of different plant extracts (12/2001)
M18: Evaluation of anthelmintic effects of inulin-rich chicory in pigs (4/2002 and 12/2003)
M19: Assessment of anthelmintic effects of different forages/plants in lambs (12/2002)
M20: Screening of anthelmintic effects of different forages/plants in pigs (12/2003)

WP7: Cultivation of bioactive forages

Workpackage number:	7		
Start date or starting event:	4/2000		
Responsible person:	CO		
Contributing persons:			
Person-months, Scientific:	2.5	Technical:	4

Objectives

- To identify limiting agronomic factors in establishment of selected bioactive forage containing condensed tannins and inulin
- To compare quality and feed value of bioactive forages
- To produce bioactive forages to be tested for antiparasitic effects in pigs and ruminants in other experiments

Description of work

7.1 In a laboratory test, the major limiting factors for establishing selected forages, including sainfoin (*Onobrychis viciifolia*), sulla (*Hedysarum coronarium*), birdsfoot trefoil (*Lotus corniculatus*), big trefoil (*Lotus pedunculatus*), chicory (*Cichorium intybus*) and Jerusalem artichoke (*Helianthus tuberosum*) will be evaluated (**task 22**).

7.2 Knowledge from the laboratory test will be used when establishing these species in small plots (ca. 30 m^2 each). Dry matter yield, weed infestation, forage quality and suitable harvest methods will be determined (**task 23**).

7.3 Based upon the outcome of the plot experiment, some or all of species will be established in fields for possible nematode control in lambs grazing the species as outlined in WP6 (**task 24**).

7.4 Chicory (or other relevant species) will be used in feeding trials with slaughter pigs (WP6/WP8) and steers (WP3/WP8). Chicory will be grown on approx. 1 ha to ensure that sufficient amounts of feed are produced. The tops of the selected species will be ensiled in large laboratory silos with conventional silage equipment. Roots will be harvested with a beet harvester and stored in the same fashion as fodder beets (*Beta vulgaris*). Based upon the trials outlined in WP8 3-4 ton DM of the bioactive crop is required (**task 25**).

Deliverables

D8: Forage available for field testing of anthelmintic activity in lambs
D9: Silage (or conserved roots) available for pigs and steers
D31: International paper

Milestones

M21: Laboratory establishment of bioactive crops completed (12/2000)
M22: Analysis of data collected from large scale production of silage to pigs and steers (10/2001+10/2002+10/2003)
M23: Evaluation of bioactive stands from small plots or grazing studies (10/2002)

WP8: Influence of bioactive forages on meat and eating quality

Workpackage number:		8			
Start date or starting event:		1/2001			
Responsible person:		LLH			
Contributing persons:		MM	SMT AR	CO	TK
Person-months	Scientific:	10.7	Technical:	13	

Objectives

- To test the effects of bioactive forages (primarily chicory) on meat and eating quality of pigs
- To test the effects of different finishing strategies with bioactive forages (chicory) on meat and eating quality of steers from pasture.

Description of work

8.1 After initial test of palatability and voluntary feed intake, the effect of including chicory (or other relevant species) in the diet of growing pigs will be investigated with regard to meat and eating quality and putative anthelmintic effects (cf. WP6). The experiment will consist of 3 groups of pigs fed 70 % of *ad libitum* of a basal concentrate diet added semi ad libitum chicory (max. 30 %)(production in WP7) and related bioactive plant(s) for 10 weeks before slaughter from 50 – 107 kg liveweight, and a control group of pigs fed 100 % (semi ad libitum) on basal concentrate diet without any bioactive forage. It is planned to perform the first experiment in autumn 2001 (October – January). All pigs in each group of the first experiment will, in accordance with task 6.5, be experimentally infected with *O.dentatum* and *A.suum* prior to the feeding experiment when the pigs are kept in groups from 30 – 50 kg liveweight and fed 100 % the basal concentrate added semi *ad libitum* grass silage. Feed stuffs relevant to practice on organic farms will be used**.** The meat quality assessments include the following parameters lean meat percent in carcass, pH1, ultimate pH, waterholding capacity (driploss), meat colour (Minolta), fatty acids and E-vitamin in raw and cooked meat, muscle glycogen, skatole in blood plasma and backfat (boar taint) of 16 male and 16 female pigs. Eating quality will include sensory profiling of *M. longissimus dorsi* of pigs at 107-kg live weight including both appearance, flavour and texture descriptors (KVL Department of Dairy and Food Science, Division of Sensory Science). Depending on the outcome of the first experiment, a second experiment with pigs in autumn 2002 – January 2003, varying the parameters mentioned. Sensoric analysis of the meat is presently not planned to be included (funding not available). (**task 26**)

8.2 Effects of 2 different finishing strategies with or without bioactive forage (4 groups) (produced in WP7) are compared (task 18) on fatty acids composition and sensory quality at slaughter. Sensory profiling and fatty acids composition will be performed as described for task 28 (**task 27**).

Deliverables

D17: Report

D34 and D36: International papers

Milestones

M24: Assessment of the influence of chicory (and a related bioactive species) on meat and sensory quality in pigs (4/2002+4/2004)

M25: Evaluation of the effect of different finishing strategies on fatty acids composition and sensory quality in steers fed a bioactive forage (6/2003)

7. Implementation and time schedule

Activities in WP1 are based on co-operation with the on-going farm research project ”Development of new organic farming systems” (1999-2003; Økodemo II), run by the Department of Agricultural Systems. DIAS. The project includes 6 private farms with a yearly production of 30-100 steers per farm. A skilled technician ensures some basic data but funding through this project will allow registrations to be intensified in relation to factorial experiments e.g. through daily recordings of the individual intake of concentrate. Field trials of WP2 are planned to take place at the research farm, Skovgård. At Skovgård, a production trial is presently carried out with 120 steers of Danish Friesian and Danish Jersey breeds grazing clover grass pastures with expected termination 2002. Different strategies are tested, varying slaughter age and fattening strategy. The large scale grazing study of WP3/WP4 is performed at a location close to Randers, at Fussingø Gods, on wet riparian pastures where suitable fenced paddocks with handling pens are available. The area was converted to organic farming several years ago. Recordings on flora, forage production etc. have been carried for 4 years and will be used for comparison with results from the present project. Steers will be housed at DIAS, Foulum. The rearing of steers is not organic as this is regarded as not essential in this context but the feeding plan will be made according to organic practice.

WP5 is performed at DIAS, Årslev, both preparation of extracts and analyses for tannin and inulin, using plants collected or grown by participants at KVL, in Foulum, Fussingø or in Årslev. Most analyses of presumably bioactive secondary metabolites have been excluded due to the budgetary restraints, even though the expertise is present in the research group. If relevant plant material shows significant anthelmintic activity in the presently applied project, additional funds will be applied for from relevant sources for this purpose.4

Bioassays of WP6 is performed at KVL, Danish Centre for Experimental Parasitology (DCEP). DCEP is permanently having a stock of pig helminths for inoculations. Sheep will be used as a ruminant model for the ease of handling and to save expenses. Ovine helminths in monoculture will be provided by Moredun Research Institute (see later). WP7 and WP8 are performed at DIAS, Foulum with assistance of researchers from KVL for sampling, handling and analysis of samples for parasitology and for assessment of sensory quality. Unfortunately, the second pig experiment mentioned in WP8 will not include sensoric analysis of the meat at KVL due to lack of funding. The expense for salary of scientific staff in WP8 is reduced to a minimum. Thus, further alternate funding for primarily sensoric profiling will be appropriate.

The project activities regarding organic steer production will form basis for Bea Nielsen’s Ph.D. study titled: Organic beef production. Bea Nielsen initiated her 4-year study in November 1998 and has so far performed a questionnaire (437 respondents) on organic farms in order to map possibilities and constraints in organic steer production. The method for intake estimation in grazing livestock was tested in 1999. Furthermore, it is the intention to include agricultural, veterinary and chemistry M.Sc. students in specific research areas where possible. Four M.Sc. students are presently involved in closely related activities: Organic steer production on wet riparian meadows (supervisor: HRA), Problems in steers associated with the transition from stable feeding to grazing (SMT), Anthelmintic properties of proanthocyanidins and related compounds (SMT) and Antiparasitic effects of garlic and legumes (SMT).

The transfer of information and research results to organic farmers and consultants will take place through direct contact in relation to the on-farm activities and through provision of written Danish guidelines on e.g. use of marginal land in steer production. Scientific papers in international journals will also be an aim in order to secure a high level of standards. The collaboration with organic farmers in e.g. WP1 will provide a means a direct transfer of practical results from the other workpackages e.g. use of a specific forage.

In October 1999, DCEP unfortunately lost its director (Professor Peter Nansen, co-applicant on the letter of intent). Dr. Darwin Murrell from USDA became the new director by July 2000. The director has expressed willingness for continued support and provision of lab facilities to this project. The centre provides a useful infrastructure for the activities in this application and a discontinuation may affect these activities adversely.

Table 3: Deliverables list

Delive-Rable No*	Deliverable title	Delivery date	Meeting[1]	Nature[2]
D1	Determinations of inulin and condensed tannins in forages	2000-2003		O
D2	Delivery of plant species from WP4 to WP5	7/2000		O
D3	First annual status report	11/2000	G1	Re
D4	Time table, version 2	11/2000	G1	
D5	Report: Development of a gut-mimetic system for extraction of bioactive secondary metabolites	12/2000		Re
D6	Extracts of cultivated plants	12/2000		O
D7	*In vitro* assays for anthelmintic activity of plant extracts	12/2000		O
D8	Forage for lambs	7/2001 7/2002		O
D9	Silage for pigs and steers	8/2001 8/2002 8/2003		O
D10	Extracts of wild plants	10/2001		O
D11	Time table, version 3	11/2001	G2	O
D12	Second annual status report	11/2001	G2	Re
D13	Paper: Feed intake in dairy breed steers on clover grass pasture and on wet riparian pasture	12/2001		Pu
D14	Paper: *In vitro* studies of the anthelmintic effect of bioactive plants on infective larvae of bovine and porcine parasites	12/2001		Pu
D15	Paper: Grass intake, liveweight gain and parasite load in steers and heifers compared to grazing strategy, sward structure and herbage quality	6/2002		Pu
D16	Paper: *In vivo* studies of the anthelmintic effect of bioactive plants on helminth parasites in sheep	6/2002		Pu
D17	Report: Preliminary report on the effect of a bioactive forage on meat and sensory quality in pigs	Medio 2002		Re
D18	Popular paper: A challenge for organic farmers: steer production for maintenance of biodiversity including bioactive plants of low-lying marginal areas (In Danish)	Medio 2002		Pop
D19	Report: Production strategies in steer production: A model	11/2002		Re
D20	Report: Grazing strategies for dairy breed steers with focus on calves	11/2002		Re
D21	Paper: Effect of different finishing strategies on steer production on organic farms	11/2002		Pu
D22	Paper: Supplementation and adaptation of calves to grazing	11/2002		Pu
D23	Paper: Evaluation of different winter feeding strategies for steers on organic farms	11/2002		Pu
D24	Popular paper: Body condition as a management tool in organic steer production	11/2002		Pop
D25	Time table, version 4	11/2002	G3	O
D26	Third annual status report	11/2002	G3	Re
D27	Paper: Organic steer production for maintenance of	Ultimo		Pu

	biodiversity of low-lying marginal areas	2002		
D28	Paper: Bioactive plants in long-term swards with a high or low botanical diversity	Ultimo 2002		Pro-in
D29	Paper: Liveweight gain, parasite load and slaughter results in steers grazing in rotational versus continuous grazing systems.	6/2003		Pu
D30	Popular paper: Steer production on marginal land	6/2003		Pop
D31	Paper: Growth and quality of bioactive plants	10/2003		Pu
D32	Time table, version 5	11/2003	G4	O
D33	Fourth annual status report	11/2003	G4	Re
D34	Paper: Effect of different finishing strategies and a bio-active forage on meat and sensory quality in steers	12/2003		Pu
D35	Identification of plant/forages with short or long term anthelmintic effects	6/2004		O
D36	Paper: Effect of chicory on meat and sensory quality in pigs	10/2004		Pu
D37	Paper: *In vivo* studies of the anthelmintic effect of bio-active plants on helminth parasites in pigs	10/2004		Pu
D38	5. and final annual status report	11/2004	G5	Re

*workpackage meetings have not been scheduled

Table 4: Time table (enclosed)

8 Collaborative partners

8.1 National collaborators

Collaboration has been established with Centre for Bioactive Natural Products (CBNP), headed by Dr. Arsalan Kharazmi, Dept. of Clinical Microbiology, University Hospital (Rigshospitalet), Copenhagen. The centre performs bioscreening of natural compounds for therapeutic use in humans and has agreed to consider screening of products from our project (anti-bacterial and possibly also immunomodulating and anti-inflammatory tests may be applicable).

Research professor Knud-Erik Bach Knudsen, DIAS, specialist in pig gastrointestinal physiology, has for the last 5 years collaborated with DCEP on the influence of diet carbohydrates on establishment, survival and fecundity of helminths in pigs. On-going studies will, if feasible, be combined with the feeding trials at DIAS planned in the present project.

Research professor Erik Steen Jensen, Agroecology, KVL will assist in assessment and establishment of bioactive legumes at KVL research farm.

The analysis method for fructans (inulin) has been developed by Susanne Lier Hansen, DIAS, in a project on onion quality (Hansen, 1999). The analysis method for chicoric acid has been developed by stud. tech. Lynette Ramsay, DIAS, in a project on quality of Danish cultivated Echinacea for production of herbal medicine. Analysis method for the sesquiterpene lactone parthenolide has been developed in a project funded by the Danish Medical Research Council (Christensen et al. 1999).

Applications for projects comprising the development of analysis methods for the sesquiterpene lactones lactucin, lactupicrin and glucosinolates have been submitted to EU 5th framework, Føtek 3 and the Danish Pesticide Tax Funds, or are presently under preparation for submission in September and October 2000.

8.2 International collaborators

Dr. Bob Coop, Moredun Research Institute, Edinburgh has agreed to provide single species infective larvae for inoculation of sheep. Further, Dr. Coop and Dr. Ilias Kyriazakis, Scotland Agricultural College will from April 2000 be involved in a project (Control of internal parasites in organic livestock without the use of pharmaceutical anthelmintics) funded by the Ministry of Agriculture, Fisheries and Food of England. Ideas and research plans will be exchanged and they may participate in meetings.

Professor D.W.T. Crompton, WHO Collaborating Centre for Soil-transmitted Helminthiasis, University of Glasgow, UK, and Dr. Peng Weidong, Jiangxi Medical Science Research Institute, Nanchang, Jiangxi, PR China, are currently working on a project on traditional chinese medicine (herb medicine) in the treatment of human *Ascaris* infections. Similarly, senior scientist, Dr. P. Waller, Swedish Veterinary Laboratory, Uppsala, is involved in screening of natural products for activity against helminths of ruminants in Kenya, funded by SIDA. These researchers will be consulted for detailed planning of experiments.

In the spring 2000, a joint Nordic veterinary research group including SMT produced and submitted for publication, a review on parasite control in livestock by use of local plants (Waller *et al*., 2000). It is the intention of the group to start a Nordic research network in this area.

9. Budget

Total budget is 6.57 mill. DKK

	2000	2001	2002	2003	2004	Total
VIP mths.	9,4	16,4	13,9	10,6	4,6	54,9
TAP mths	10,5	20,1	18,7	10,6	2,2	62,1
VIP, kr	342.055	617.758	542.096	438.588	200.242	2.140.739
TAP, kr	241.800	476.990	460.890	261.521	47.000	1.488.201
Operation	367.167	717.330	536.869	151.863	72.832	1.846.061
Overhead	190.204	362.416	307.971	170.394	64.015	1.095.000
Total	1.141.226	2.174.494	1.847.826	1.022.366	384.089	6.570.000

MM, Dept. of Dairy and Food Science, KVL

	2000	2001	2202	2003	2004	Total
VIP mths.	0,0	0,0	1,5	1,5	0,0	3,0
TAP mths.	0,0	0,0	0,0	0,0	0,0	0,0
VIP, kr	0	0	63.000	63.000	0	126.000
TAP, kr	0	0	0	0	0	0
Operation	0	0	15.333	15.334	0	30.667
Overhead	0	0	15.667	15.667	0	31.333
Total	0	0	94.000	94.001	0	188.000

LLH, Dept. of Animal Product Quality, DIAS

	2000	2001	2202	2003	2004	Total
VIP mths.	0,0	1,8	1,7	1,6	2,6	7,7
TAP mths.	0,0	3,2	3,2	4,4	2,2	13,0
VIP, kr	0	66.000	66.000	66.000	107.864	305.864
TAP, kr	0	71.000	71.000	96.000	47.000	285.000
Operation	0	79.250	79.250	79.584	67.719	305.803
Overhead	0	43.250	43.250	48.317	44.517	179.333
Total	0	259.500	259.500	289.901	267.100	1.076.000

ABH, Dept. of Landscape Ecology, NERI/DMU

	2000	2001	2202	2003	2004	Total
VIP mths.	0,4	3,7	0,9	0,0	0,0	5,0
TAP mths.	0,0	1,3	0,4	0,0	0,0	1,7
VIP, kr	15.000	140.000	33.000	0	0	188.000
TAP, kr	0	30.000	10.000	0	0	40.000
Operation	0	24.500	10.000	0	0	34.500
Overhead	3.000	38.900	10.600	0	0	52.500
Total	18.000	233.400	63.600	0	0	315.000

LN, Dept. of Crop Physiology and Soil Science, DIAS

	2000	2001	2202	2003	2004	Total
VIP mths.	0,5	2,9	2,0	0,0	0,0	5,4
TAP mths.	0,04	2,56	2,1	0,0	0,0	4,7
VIP, kr	19.000	121.000	85.000	0	0	225.000
TAP, kr	1.000	66.000	55.000	0	0	122.000
Operation	1.000	33.500	31.000	0	0	65.500
Overhead	4.200	44.100	34.200	0	0	82.500
Total	25.200	264.600	205.200	0	0	495.000

HRA, Dept. of Animal Nutrition and Physiology, DIAS and TK, Dept. of Agricultural Systems, DIAS

	2000	2001	2202	2003	2004	Total
VIP mths.	2,0	3,0	3,0	3,0	2,0	13,0
TAP mths.	1,0	1,0	1,0	1,0	0,0	4,0
VIP, kr	76.000	119.700	125.685	131.969	92.378	545.732
TAP, kr	27.800	29.190	30.650	32.182	0	119.822
Operation	50.000	270.000	228.000	0	3.113	551.113
Overhead	30.760	83.778	76.867	32.830	19.098	243.333
Total	184.560	502.668	461.202	196.981	114.589	1.460.000

KB, Dept. of Horticulture, DIAS Årslev

	2000	2001	2002	2003	2004	Total
VIP mths.	2,0	0,5	0,3	0,5	0,0	3,3
TAP mths.	3,0	0,5	0,5	0,2	0,0	4,2
VIP, kr	92.000	24.000	15.000	27.000	0	158.000
TAP, kr	68.000	12.000	12.000	6.000	0	98.000
Operation	36.000	8.000	6.333	7.000	0	57.333
Overhead	39.200	8.800	6.667	8.000	0	62.667
Total	235.200	52.800	40.000	48.000	0	376.000

CO, Dept. of Crop Physiology and Soil Science, DIAS

	2000	2001	2002	2003	2004	Total
VIP mths.	0,5	0,5	0,5	1,0	0,0	2,5
TAP mths.	1,0	1,5	1,5	0,0	0,0	4,0
VIP, kr	21.500	21.500	21.500	43.000	0	107.500
TAP, kr	25.800	51.600	51.600	0	0	129.000
Operation	3.000	35.000	35.000	3.833	0	76.833
Overhead	10.060	21.620	21.620	9.367	0	62.667
Total	60.360	129.720	129.720	56.200	0	376.000

AR, Danish Centre for Experimental Parasitology, KVL

	2000	2001	2202	2003	2004	Total
VIP mths.	2,0	3,0	3,0	2,0	0,0	10,0
TAP mths.	0,0	2,0	2,0	3,0	0,0	7,0
VIP, kr	60.000	94.500	99.225	69.458	0	323.183
TAP, kr	0	46.200	48.510	76.403	0	171.113
Operation	19.371	40.000	35.000	16.000	2.000	112.371
Overhead	15.874	36.140	36.547	32.372	400	121.333
Total	95.245	216.840	219.282	194.233	2.400	728.000

SMT, Dept. of Animal Science and Animal Heatlh, KVL

	2000	2001	2202	2003	2004	Total
VIP mths.	2,0	1,0	1,0	1,0	0,0	5,0
TAP mths.	5,5	8,0	8,0	2,0	0,0	23,5
VIP, kr	60.000	31.500	33.075	34.729	0	159.304
TAP, kr	121.000	184.800	194.040	50.936	0	550.776
Operation	257.333	215.345	83.909	30.000	0	586.587
Overhead	87.667	86.329	62.205	23.133	0	259.333
Total	526.000	517.974	373.229	138.797	0	1.556.000

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