

There for the picking: cheap feed options and worm treatments

RIU

Validated RNRRS Output.

Research in Zimbabwe, Tanzania, Uganda, India and Kenya has identified tree fruits as a promising option for improving the diets of goats. Poor goat keepers can't afford to buy commercial feeds to supplement diets in the dry season. This causes slow growth and high death rates among kids—which are mainly born either at the end or at the beginning of the dry season. Tree fruits are a good cheap option to feed pregnant or suckling goats, because they can easily be collected and stored for use when needed. Related research in Tanzania has also shown that tannin-rich tree forages could help to reduce the amount of worms in the stomachs of sheep, improving productivity and the animals' health.

Project Ref: **LPP16:**

Topic: **2. Better Lives for Livestock Keepers: Improved Livestock & Fodder**

Lead Organisation: **Smith, T. (Independent), UK**

Source: **Livestock Production Programme**

Document Contents:

[Description](#), [Validation](#), [Current Situation](#), [Current Promotion](#), [Impacts On Poverty](#), [Environmental Impact](#), [Annex](#),

Description

LPP16

Research into Use

NR International
Park House
Bradbourne Lane
Aylesford
Kent
ME20 6SN
UK

Geographical regions included:

[India](#), [Kenya](#), [Mozambique](#), [Swaziland](#), [Zimbabwe](#),

Target Audiences for this content:

[Livestock farmers](#), [Forest-dependent poor](#),

A. Description of the research output(s)

1. Working title of output or cluster of outputs.

In addition, you are free to suggest a shorter more imaginative working title/acronym of 20 words or less.

The role of tanniferous tree products for improved livestock productivity in semi-arid regions

2. Name of relevant RNRRS Programme(s) commissioning supporting research and also indicate other funding sources, if applicable.

Livestock Production Programme

3. Provide relevant R numbers (and/or programme development/dissemination reference numbers covering supporting research) along with the institutional partners (with individual contact persons (if appropriate)) involved in the project activities. As with the question above, this is primarily to allow for the legacy of the RNRRS to be acknowledged during the RIUP activities

R7351

University of Reading T. Smith, E. Owen, I. Mueller-Harvey
Matopos Research Station (Dept. of Agricultural Research and Extension)
J.L.N. Sikosana, V. Mlambo.
(R 6608 and R 5851, ZC 0208, ZC 0305)

R 7424

University of Nottingham: P. J. Buttery, D. Wakelin, J. Dawson
Sokoine University of Agriculture: L.A. Mtenga, A.E. Kimambo, A.
A. Kassuku, R. A. Max
(ZC0304) also R6954 (ZC0067)

4. Describe the RNRRS output or cluster of outputs being proposed and when was it produced? (**max 400 words**). This requires a clear and concise description of the output(s) and the problem the output(s) aimed to address. Please incorporate and highlight (in bold) key words that would/could be used to select your output when held in a database.

R7351 (1999-2005) addressed **dry season** nutritional constraints to goat production on **semi-arid Acacia** thornveld. Goat keepers cannot afford commercial feeds. Rainfall is limited, droughts are common. Most kids are born at the beginning or end of the dry season. **Tree fruits (pods)** are a renewable resource, moderately-rich in protein. Their feeding value was assessed. The issues addressed were:

- a) **Kid mortality** (can be 50 % especially in multiple births)
- b) **Kid Growth rate**
- c) **Tree Species** (chemical composition and nutritive value)
- d) **Tannins** (chemistry and nutritional effects)

e) **Treatment of fruits** to improve their nutritive value

Kid mortality was reduced, especially in twins, and growth rate increased, by feeding does kidding at the end of the dry season, 200g of pods per day for 45 days before and after kidding. Of the six fruits investigated, ***Dichrostachys cinerea*** was the best. However, a PRA study indicated farmers preferred fruits common to their locality. Collection and storage was not a problem on-farm. Improved nutritive value was achieved by soaking fruits in wood ash solution. ***Acacia nilotica*** fruits require more research before being promoted (but they are readily eaten by grazing animals) (Mlambo, 2002; Smith *et al.*, 2005, Annex C). Collection of pods raised no environmental issues. Techniques used here could be adopted elsewhere to evaluate other species, both for feeding value and the nature and amount of tannins.

R7424 investigated using **tannins** to reduce gastrointestinal worm infections in small ruminants to increase **productivity**. Worms are a major constraint to livestock productivity (Gill and Le Jambre, 1996, Annex D), especially in the tropics (Perry, *et al.* 2002 Annex D). Control of **worms** is mainly by the use of anthelmintic drugs, but problems include increasing resistance (Gill and Le Jambre, 1996, Annex D), high cost and unavailability (Hammond *et al.* 1997)). Other methods of control are required. Tannin-rich forages reduced worm burdens and improved performance (Niezen *et al.*, 1993, Annex D) in **sheep**. *In vitro* studies in the UK and Tanzania using commercial tannins and extract from selected browse leaves, against mice and goat worms, showed significant anthelmintic activity against all worms tested (Max 2003, Annex C). In *in vivo* studies involving experimentally and naturally infected sheep and goats, tannin drenches reduced faecal egg counts (FEC) by 75% and worm burdens of sheep infected by *Haemonchus contortus* by 86% (Max *et al.* 2005, Annex C). The later studies with sheep were conducted under on- farm conditions, albeit on the experimental farm of the University of Sokoine. Surprisingly tannin drenches neither reduced FEC nor worm burdens in **goats. This surprising result requires further investigation**. In conclusion, tannins can be used as a worm remedy in sheep at least. The use of tannins as anthelmintics should be combined with selective use of anthelmintics, improved nutrition and grazing management.

5. What is the type of output(s) being described here?

Please tick one or more of the following options.

Product	Technology	Service	Process or Methodology	Policy	Other Please specify
	X		X		

6. What is the main commodity (ies) upon which the output(s) focussed? Could this output be applied to other commodities, if so, please comment.

Meat, milk and manure; to achieve the objectives of R7351 it was necessary to maximise milk production to ensure kid survival without reducing the milk available for household use; increased growth is required for timely breeding of female kids and achievement of early slaughter weight in males.

In this study goats were used but tree fruits also have a role in cattle production, especially where forage supply is constrained. There are also a large number of trees, both indigenous and introduced that have not been fully

evaluated. The processes used in this study could be adapted as a template for evaluating other species.

7. What production system(s) does/could the output(s) focus upon?

Please tick one or more of the following options. Leave blank if not applicable

Semi-Arid	High potential	Hillsides	Forest-Agriculture	Peri-urban	Land water	Tropical moist forest	Cross-cutting
X R7351			X R7351	X R7351			X R7424

Because tree fruits are easy to collect and transport, they can be fed at the site of production or moved for sale in areas of need.

8. What farming system(s) does the output(s) focus upon?

Please tick one or more of the following options (see Annex B for definitions).

Leave blank if not applicable

Smallholder rain-fed humid	Irrigated	Wetland rice based	Smallholder rain-fed highland	Smallholder rain-fed dry/cold	Dualistic	Coastal artisanal fishing
X R7424	X R7351		X R7424	X R7351 R7424	X R7351	

9. How could value be added to the output or additional constraints faced by poor people addressed by clustering this output with research outputs from other sources (RNRRS and non-RNRRS)? (max. 300 words).

R7351 addressed dry season forage shortages. Tree fruits are a cheap source of protein, a nutrient lacking in dry season forages (sparse grazing and fibrous crop residues). Lack of nutrients results in high kid mortality (especially in twin-born kids) and low kid growth rates, thereby reducing potential income to resource-poor goat keepers. Fruits are often freely available and collection and storage relatively easy. Treatment with wood ash to improve nutritive value is cheap and easy to apply. Collection of fruits, either on contract or for sale, can provide money for non-livestock owners (Meru District of Kenya through contact via the Link project [R7798]). The “Desert Margins Programme” operating across eight countries in central and southern Africa is promoting the outcomes from R7351 in Zimbabwe.

R7424 Integrating the use of tannins with other practices to reduce worms can reduce cost and slow development of resistance. The FAMACHA© system (R8151) can identify animals in need of treatment (van Wyk *et al.*, 1997; Malan *et al.*, 2001, Annex D). Controlled grazing can also reduce worm burdens. Feeding, especially with nitrogen-rich feeds, such as tree fruits (R7351), molasses/urea mixture or blocks and browse leaves increases the ability of animals to withstand parasites.

Please specify what other outputs your output(s) could be clustered. At this point you should make reference to the circulated list of RNRRS outputs for which proformas are currently being prepared.

R7351 Outputs link to all programmes concerned with dry season feeding and feed scarcity. Goats were targeted, but tree fruits are fed to cattle, as protein supplements or during drought in bushmeal (Holness, 1988, Annex D). Feeding tree fruits is a component of utilising browse. Relevant proforma to R7351 include:

- Variability and productivity of semi-arid grazing areas (R6984; R8476; ZC0291)
- Crop residues, handling and as forage (R5188, R6619; R7346; R7955; R8339; R8296)
- Farm Africa (R7634)
- Smallholder dairying toolbox (ZC0261)
- Forage conservation (R7010)
- Small stock toolbox (ZC0243)
- Livestock in challenging environments-coping strategies for progress
- Link project and associated publications (R7998; ZC0304; ZC0305; ZC0213)

Validation

B. Validation of the research output(s)

10. How were the output(s) validated and who validated them?

Please provide brief description of method(s) used and consider application, replication, adaptation and/or adoption in the context of any partner organisation and user groups involved. In addressing the “who” component detail which group(s) did the validation e.g. end users, intermediary organisation, government department, aid organisation, private company etc... This section should also be used to detail, if applicable, to which social group, gender, income category the validation was applied and any increases in productivity observed during validation (max. 500 words).

R7351

- Literature review and consultations, including a PRA study (Kindness et al {1999}, see FTR and publications, Annex C)
- Laboratory studies in R7351 characterised, by both chemical and in vitro techniques the nutritive value of the selected tree fruits. The tannin profiles were also determined and published in a PhD thesis (Mlambo, 2002) and refereed papers (FTR and publications, Annex C).
- Animal experimentation (on-station and on-farm). The on-farm studies were ‘farmer-managed’ research; all the farmers (66) concerned, as well as several neighbouring farmers, continued feeding tree fruits after the end of the trials. Farmers selected to feed the fruits most readily available in their locality, as reported in the PRA study (Kindness *et al.*, 1999, Annex C). The project has characterised several fruit species that fit the criteria to be used as feed.
- Published papers and conference proceedings (see FTR R7351 for publications, Annex C)

R7424

In vitro studies were carried out the UK (using parasites isolated from mice) and Tanzania (using parasites isolated from goats) using commercial tannins and extract from selected browse leaves to control nematodes.

These experiments were followed by *in vivo* experiments where tannins were administered as a drench to sheep and goats. The tannin content of the species available in the Morogoro region of Tanzania showed that *A. polyacantha* leaves had the highest level of condensed tannins and were used in feeding trials with sheep and goats, some evidence for reduction in parasite burden was noted. The major effects were noted when oral drenches of extracted tannin were used on goats.

Results were communicated in various conferences, workshops and final technical report (FTR and publications, Annex C). Papers were published in conference and workshop proceedings and peer reviewed journals (Max *et al.*, 2005 a & b, Annex C).

WHO?

- Researchers (nutritionists, animal scientists and parasitologists; both projects).
- R7351, post project promotion by extension service and NGOs, willingness of farmers to adopt.

Social groups –

R7351 Moderate poor; extreme vulnerable poor (asset less, women headed households); extreme dependent poor (disabled, chronically sick etc.); children of the extreme poor. Goat keepers within these groups having the option of feeding; others can be employed to collect fruits for neighbouring farmers or sale.

R7424 Not yet field tested although the studies with sheep given oral drenches were conducted under on farm conditions at the Sokoine University with naturally infected animals.

11. *Where and when have the output(s) been validated?*

Please indicate the places(s) and country(ies), any particular social group targeted and also indicate in which production system and farming system, using the options provided in questions 7 and 8 respectively, above (max 300 words).

R7351

- Mbembeswana, Homestead, Tudi 2 in Zimbabwe (1999 – 2004). The farmers concerned were in the Moderate poor, Extreme vulnerable poor and Women headed households poverty groups (semi-arid; smallholder rain fed dry/cold) In Zimbabwe there are 1.3 million smallholder and communal area farmers owning 2.9 million goats (they also own 4.6 million cattle). In natural regions 4 and 5 (semi-arid and arid) half of the land is covered by indigenous trees. See also FTR executive summary and publications list (Annex C)
- India (project R6953, Rajasthan), in the semi-arid production system in the smallholder rain fed dry/cold farming system. Tree fruits were used to replace barley grain in the diets of breeding goats, thus markedly reducing the cost of supplementation.
- Kenya, (Project R7634), also in the semi-arid production system in the smallholder rain-fed dry/cold farming system. Two outlets are operating; collecting and feeding; buying, from up to 200 km distance and feeding (thus creating work).
- In Mozambique the Livestock Development Strategy (1997) and Livestock Development Policy (Draft, 2004) support increased goat keeping as a pathway out of poverty (PARPA 1 [2000] and PARPA 11 [2006]). Estimates suggest 1500-2000 households will benefit directly and 4.2 million people indirectly (of which 2.1 million are regarded as poor) (see Annex D for refs).

- Feed shortages, the cost of protein supplements, greater dependence on crop residues and the need to conserve trees are all acknowledged for both Kenya and Tanzania (MF&LD, 2006a and b, MLD, 2006, Annex D), demonstrating a niche for the strategic use of tree fruits. Mtengeti *et al.* (2004, 2005) (Annex D) list several tree species, in Southern Tanzania, whose fruits should be evaluated as feed.
- Swaziland: evaluation of *Dichrostachys cinerea* fruits as a protein supplement in diets based on sugar cane tops. Farmers are adopting the technology ahead of the results of the study.

R7424

- For project R7424 see executive summary and attached key publications list (Annex C)

Current Situation

C. Current situation

12. *How and by whom are the outputs currently being used? Please give a brief description (max. 250 words).*

Discussions in Nairobi, 2-4 October, 2006, involving collaborators from Ghana, Kenya, Tanzania, Uganda, Zimbabwe and UK preparing proforma (R5188, R6619, R7955, R7798, R7424, R7351, R6954, ZC0289) concluded:

R7351

- Tree fruits are a readily available and cheap source of crude protein, usually eaten as the fruits fall from the trees, but can be collected and stored for strategic supplementation of very poor quality forage diets, e.g. those based on crop residues, later in the season
- The tree fruits are being collected, by farmers or paid labour, as they fall from the trees (this occurs while there is still some grazing available) and are kept in a dry store (often a drum or a sack). They are fed strategically to animals, in late pregnancy or in lactation. Fruits collected by non-stock owners are sold or bartered for grain for household consumption.
- The outputs are used by livestock keepers for feeding and non-livestock keepers for earning money.

R7424

- A tannin extract very cheaply obtained from the local leather industry has been used as drench to deworm infected sheep at the university farm at Sokoine Agricultural University. The drench was shown to be very effective, holding back infection for at least a month. This procedure needs further testing on-farm. The reason for there being little effect on goats requires further investigation under on farm conditions.

13. *Where are the outputs currently being used? As with Question 11 please indicate place(s) and countries where the outputs are being used (max. 250 words).*

- **R7351** Zimbabwe, The semi-arid provinces of Matabeleland (North and South); Tanzania, Dodoma

region; Uganda (Karamoja); India, Rajasthan; Kenya, Meru; Swaziland). At each site the fruits are collected and stored, prior to being used as a cheap protein feed to supplement poor quality forage.

- **R7424** Tanzania, Sokoine University of Agriculture . We know of several groups that have also tried the use of tannins under conditions similar to those seen on farm. They have had variable results.

14. *What is the scale of current use? Indicating how quickly use was established and whether usage is still spreading (max 250 words).*

R7351

- Traditionally fruits were collected and sold to commercial farmers
- The feeding value and use of pods was not appreciated by smallholders
- The project output has characterised and indicated the amounts to be fed
- By working with farmers, extensionists and NGOs from the start of the project the value of pods was quickly realised
- The technology is still spreading as the number of farmers collecting and storing is increasing annually.

R7424 Several studies appear to being undertaken, especially in temperate research facilities. R7424 appears to be the only systematic study being undertaken under near on farm conditions in the tropics. The concept has resulted in considerable activity in several countries.

15. *In your experience what programmes, platforms, policy, institutional structures exist that have assisted with the promotion and/or adoption of the output(s) proposed here and in terms of capacity strengthening what do you see as the key facts of success? (max 350 words).*

R7351

- Agricultural shows (National, Provincial and District shows in Zimbabwe)
- Media (in Zimbabwe: radio [Umlimi Walamhla], TV [Talking Farming], newspapers [Sunday News and Umthunywa])
- Farmer field schools (in Matabeleland North Province) and other farmer-to farmer training initiatives
- Included in DFID/LPP promotional tour of southern/central African states
- Visits (to and off station by farmers, extension workers, NGOs, tertiary education establishments and school parties)
- Refereed papers in scientific journals, conference proceedings, farmer orientated publications and reports (annual reports etc.) (see R7351 Executive Summary and key publication list)
- Inclusion in nutrition courses at tertiary education institutions
- In a textbook *Livestock & Wealth Creation [ZC0123]* (chapters 10 and 11,)
- Link publications (R7798)
- One PhD study and two first degree third year dissertation studies

R7424

- Proceedings, journals and reports
- Part of a book chapter (*Livestock & Wealth Creation*) [ZC0123]
- Contributions to Link publications and ZC0304 e.g. *Technical manual for worm management in small ruminants* (Max *et al* 2006, Annex C)).
 - publications
 - A PhD study (Annex C).

The key facts of success:

R7351 and 7424

- Clearly defined problems, both (high kid mortality; worm control) seriously affecting the profitability of smallholder goat keeping
- Simple and easily affordable solutions; with R7351 a solution that can also generate income for those without livestock
- A dedicated team of stakeholders, including researcher, extension and farmers

Current Promotion

D. Current promotion/uptake pathways

16. **Where** is promotion currently taking place? Please indicate for each country specified detail what promotion is taking place, by whom and indicate the scale of current promotion (**max 200 words**).

R7351

- Zimbabwe; North and South Mataberland and Midland Provinces (Zvishavane); extension workers (Dept of Agricultural Research and Extension) and NGOs
- Tanzania (Dodoma Region, extension workers and NGOs)
- Kenya (Meru District, Farm Africa)
- Swaziland, university staff working in cane sugar growing areas
- Uganda (Karamoja Province, Farm Africa)
- Asia (Link project [R7798] proceedings)

R7424

Link project proceedings, publications and conferences are the main promotion methods which have so far been used to promote the output to researchers. A *Technical manual for worm management in small ruminants* [ZC0304] and a radio interview Max, R.A. (2005) A plant-based treatment for roundworms? Other presentations include: "Communicating science for sustainable development". September 2005 edition, (<http://www.agfax.net>): And an AGFAX radio interview by WREN Media, UK.

17. **What are the current barriers preventing or slowing the adoption of the output(s)?** Cover here institutional issues,

those relating to policy, marketing, infrastructure, social exclusion etc. (max 200 words).

R7351

- Extensions services are constrained by government budgets
- High staff turnover
- Land tenure system under communal land ownership (farmer may have no control over use of trees)
- Marketing of goats not formalised; often on a per head basis to a residual buyer, ignoring condition of the animal
- Climate (excess heavy rainfall and strong winds during flowering reduces fruit production)
- Isolated cases of local by-laws preventing collection and selling of pods
- Negative effects if used as a sole source of supplemental protein (e.g. tainted milk and poisoning; abortions have been reported when excessive amounts of *Acacia nilotica* have been consumed). The links between dietary tannins and animal production need further investigation (Mueller-Harvey, 2006, Annex D).
- Benefits from deactivating tannins with polyethylene glycol (PEG) require an energy supplement to capture the released N. At present this approach is uneconomic
- HIV-AIDS affects dissemination, labour availability and numbers of livestock a household can handle
- Farmers need advice on all aspects of goat keeping-feeding, disease control, breeding, simple record keeping and marketing

R7424

There is a need for further on farm trials to work out dosing strategies etc. and if these are successful, the information needs to be disseminated so that the technique can be 'marketed'. Two different tannin extracts (Quebracho from Argentina and wattle from Tanzania have been shown to be effective. Since tannin extracts and indeed the tannins do vary from country to country and between plant species it may be necessary to check other products.

18. What changes are needed to remove/reduce these barriers to adoption? This section could be used to identify perceived capacity related issues (max 200 words).

R7351

- Farmer-to-farmer training should be encouraged
- Farmers should be trained and encouraged to manage local natural resources
- Promotion of farmer-led groups
- Involvement of politicians and policy makers through talking to and supplying relevant information (keep them fully informed)
- Structuring of the marketing system
- Give enough relevant and user friendly information/guidelines about observing recommended amounts of tree fruits to be fed
- The outputs contribute to improving dry season feeding, either through improved use of crop residues or other poor quality forage, by supplying a cheap available protein source (see proforma '*Networking as a tool to disseminate information and training materials*', R7798 etc.)

R7424

- Validation on-farm is required to confirm dosing schedule and to test efficacy in goats and cattle (see 12 above).

19. *What lessons have you learnt about the best ways to get the outputs used by the largest number of poor people? (max 300 words).*

R7351 and R7424

- Ensure that farmers, extension workers and NGOs are fully involved as equal partners, from the outset, with all stages of the project
- Encourage education to reduce illiteracy
- Note and make use of indigenous knowledge
- Demonstrations in farmer fields where a farmer is a researcher (to encourage local ownership of the project)
- Support demonstrations with simple and clear leaflets (if these are available electronically translation into the vernacular can be done as required)
- Train interested and innovative farmers as farmer-trainers
- Make sure the politicians and policy makers are fully informed of the potential of tree fruits in livestock feeding and income generation

Impacts On Poverty

E. Impacts on poverty to date

20. *Where have impact studies on poverty in relation to this output or cluster of outputs taken place? This should include any formal poverty impact studies (and it is appreciated that these will not be commonplace) and any less formal studies including any poverty mapping-type or monitoring work which allow for some analysis on impact on poverty to be made. Details of any cost-benefit analyses may also be detailed at this point. Please list studies here.*

R7351

Within the scope of the project, the full impact assessment was not possible. But there are indications that goat kid survival, especially in kids from multiple births, was substantially increased. Mortality rates in Matabeleland South Province of Zimbabwe fell from around 50 % to 24 % (increased awareness of management issues among farmers is expected to reduce this figure further). Uptake by farmers outside the targeted communities suggests a perceived benefit aided by an inability to purchase concentrates (a constraint facing smallholder farmers in most of the drier areas of developing countries).

R7424

Within the scope of the project, a full impact assessment was not possible or desirable. But there are indications that wattle tannin reduces faecal egg count by 75% and worm burden in sheep by 86 % this can

increase lamb survival and thus contribute to poverty reduction. Further work was required before true on farm trials could be undertaken.

21. *Based on the evidence in the studies listed above, for each country detail how the poor have benefited from the application and/or adoption of the output(s) (max. 500 words):*

- *What positive impacts on livelihoods have been recorded and over what time period have these impacts been observed? These impacts should be recorded against the capital assets (human, social, natural, physical and, financial) of the livelihoods framework;*

R7351

- Human; food security has increased
 - Social; increased goat numbers improve peoples' perceptions of their wealth standing
 - Natural; awareness of the value of trees increased
 - Physical; effects result from improved family nutrition
 - Financial; for livestock keepers whose flocks have increased in size, they have an increased capital asset; for those selling excess stock there is more money; for those collecting fruits as wage earners there is extra cash
- *For whom i.e. which type of person (gender, poverty group (see glossary for definitions) has there been a positive impact;*

Moderately poor livestock keepers

Extreme vulnerable poor

- Asset-less or near asset-less - as wage earners
 - Women headed households - livestock keepers and wage earners
- Extreme dependent poor-disabled and chronic sick - wage earners
Children of the extreme poor-wage earners

- *Indicate the number of people who have realised a positive impact on their livelihood;*

Using pods is becoming an acceptable practice particularly in the dry areas of Zimbabwe (up to 1.3 million farming families).

- *Using whatever appropriate indicator was used detail what was the average percentage increase recorded*

Mortality on kids was halved. Farmers attributed this to improved nutrition

R7424

- Survival of lambs as a result of deworming using tannins is likely to increase lamb population and improve food security of the farmers. Need to have definitive data on the efficacy of the technique in other species.

Environmental Impact

H. *Environmental impact*

24. *What are the direct and indirect environmental benefits related to the output(s) and their outcome(s)? (max 300 words)*

This could include direct benefits from the application of the technology or policy action with local governments or multinational agencies to create environmentally sound policies or programmes. Any supporting and appropriate evidence can be provided in the form of an annex.

R7351

- Demonstrating the value of tree fruits is expected to increase people's perceptions of the value of fruit bearing trees. This should increase indiscriminate felling, thereby decreasing the speed of degradation of rangelands (Wangiri, 1996, Annex D).
- The presence of adequate tree cover provides wild life habitat, including birds and bees, thus ensuring biodiversity

R7424

- The use of tannins as dewormers will reduce contamination of the environments and food chain by anthelmintics drugs.

25. *Are there any adverse environmental impacts related to the output(s) and their outcome(s)? (max 100 words)*

R7351

- Improper (early) harvesting of tree pods could be deleterious to the trees through leaving entry points for foreign bodies. Animals will not eat unripe pods.
- Pod collection for sale could deplete the soil of minerals (e.g. phosphorous) which are unlikely to be replaced
- Increased number of animals due to increased survival when not culled (females) or marketed according to a plan will lead to over grazing/browsing resulting in the cycle of degradation and erosion in extreme cases leading to desertification (Smith and Wangiri, 1996, Annex D)

R7424

- Increased number of animals due to increased survival where people use animals as banks, instead of income generating activities, may lead to overstocking and soil degradation leading to desertification

26. *Do the outputs increase the capacity of poor people to cope with the effects of climate change, reduce the risks of natural disasters and increase their resilience? (max 200 words)*

R7351 and R7424

- Increased aridity in Africa is predicted as a result of global warming. To sustain livestock productivity it

will be necessary to research and promote the increased production of forage in semi-arid and arid environments. Acacia and related tree species are well adapted to harsh environments

- The presence of trees, through their roots, reduces the effects of run-off, especially when grass cover is poor.

Annex

Annex C

FTR R7351-EXECUTIVE SUMMARY

T. Smith, E. Owen, I. Mueller-Harvey, V. Mlambo and J.L.N. Sikosana

Production from smallholder owned goats in the semi-arid tropics is constrained by dry season feed shortages. Kid mortality is high and growth rates of kids weaned at the onset of the dry season delay attainment of slaughter weight in males and breeding in females. However, because of the prohibitive cost of purchased feed, only locally available, probably non-conventional, feeds can be considered as supplements. In Southern Zimbabwe, the natural vegetation, typical of communal grazing areas, consists of annual and perennial grasses and trees and shrubs, many of which are *Acacia* species. In this project tree fruits, from *Acacia* and other available species were evaluated as dry season protein supplements for goats.

Research included a participatory rural appraisal (PRA) and on-farm observation, laboratory and *in vivo* assessments of selected species of tree fruits, on-station and on-farm measurements of animal responses and dissemination activities. Simple, safe methods of mitigating the anti-nutritional affects of tannins were sought.

The PRA revealed that some farmers collect and store fruits to use as dry season feed, although they have no technical support. In some years fruits are marketed. Preferred species tend to reflect local availability. From the findings of the PRA, stakeholder meetings and discussions with farmers, the following species were selected for evaluation: *Acacia erioloba*; *A. erubescens*; *A. nilotica*; *A. tortilis*; *Dichrostachys cinerea*; *Piliostigma thonningii*. Probably the most widespread species in Southern Africa, *Acacia karroo*, is dehiscent and unsuitable for collection and storage. Studies elsewhere indicated that removal of moderate amounts of fruits is unlikely to effect regeneration of the bush.

All fruits contained over 100 g CP/kg DM, and, except *A. nilotica*, were high in fibre. Of the two species most available on-farm during the project, *A. nilotica* contained more total carbohydrates and total phenolics than *D. cinerea*. The addition of polyethylene glycol (PEG) increased cumulative gas production, up to 95 h, and organic matter degradability in *D. cinerea*, *A. erioloba* and *A. nilotica*. However, DM intake, digestibility and N retention from hay plus supplement were suppressed when *A. nilotica* was fed and increased with *D. cinerea*, compared to the other fruits offered. In controlled feeding trials, supplements of *D. cinerea* resulted in increased growth rates and reduced kid mortality, especially of twin-born kids. Milk available to the household was also increased. On-farm treatment to break the tannin/protein complex requires a safe, cheap and available agent. Wood ash proved effective in the laboratory, especially without PEG (unaffordable on-farm) and is currently being tested in trials with goats (preliminary results suggest that soaking whole fruits in wood ash solution for 40 hours increases milk

yield in does and, therefore, growth rate in kids). On-farm a collegiate approach to evaluation was taken, with goats being offered available fruits. Farmers have expressed satisfaction with the technology. Many have also been persuaded to keep a notebook of major events affecting their goats.

Dissemination has been through published papers (scientific, proceedings and popular articles), the media (radio and television), contributions to Farmer Field Schools, farmer meetings and station visits. An accurate estimate of the number of farmers adopting this technology is not possible, but indications are positive. Increased productivity from the smallholder owned goat herd will improve livelihoods of resource-poor livestock keepers in semi-arid conditions.

Publications

Smith, T., Owen, E., Mueller-Harvey, I., Mlambo, V. and Sikosana, J.L.N. (1999). Introduction to new projects, 7: Increasing the productivity of smallholder owned goats on *acacia* thornveld. In (eds. T. Smith, J. Mhunduru, J.I. Richards): *Proceedings of the second workshop on Livestock Production Programme projects in Zimbabwe, held at Ingwe Lodge, Matobo, 22-23 February 1999*. Natural Resources International Ltd. (NRIL), pp. 59-60.

Mlambo, V., Mould, F.L., Mueller-Harvey, I., Smith, T. and Owen, E. (2000). *In vitro* characteristics of separated tree components with added polyethylene glycol (PEG) as a diagnostic tool for effect of tannins. EAAP Satellite Symposium, Wageningen, pp. 80-81.

Mlambo, V., Mould, F.L., Mueller-Harvey, I., Owen, E., Doves, L.R., Mugabe, P.H. and Smith, T. (2001). Chemical composition and *in vitro* fermentation of *acacia* and other tree pods. In (eds. T. Smith and S.H. Godfrey): *Sustaining livestock in challenging dry season environments; Proceedings of the third workshop on Livestock Production Programme projects, 26-28 September 2000 at Ingwe Lodge, Matobo*. Natural Resources International Ltd., pp. 104-108.

Sikosana, J.L.N., Smith, T., Owen, E., Mueller-Harvey, I. and Mlambo, V. (2001). Increasing the productivity in smallholder owned goats on *acacia* thornveld. 1. Goat feeding strategies. In (eds. T. Smith and S.H. Godfrey): *Sustaining livestock in challenging dry season environments; Proceedings of the third workshop on Livestock Production Programme projects, 26-28 September 2000 at Ingwe Lodge, Matobo*. Natural Resources International Ltd., pp. 98-103.

Smith, T., Mlambo, V., Sikosana, J.L.N., Owen, E., Mueller-Harvey, I., Buttery, P.J. and Conroy, C. (2001). Use of tanniferous feeds to improve smallholder goat production: Project to link R7424 (Tanzania), R7351 (Zimbabwe) and R6953 (India) to increase dissemination outputs and impact (R7798). In (eds. T. Smith and S.H. Godfrey): *Sustaining livestock in challenging dry season environments; Proceedings of the third workshop on Livestock Production Programme projects, 26-28 September 2000 at Ingwe Lodge, Matobo*. Natural Resources International Ltd., pp. 117-119.

Mlambo, V., Mould, F.L., Smith, T., Owen, E. and Mueller-Harvey, I. (2002). The evaluation of *acacia* and other tree pods for goats: influence of rumen fluid source and polyethylene glycol addition on *in vitro* gas production. *Proceedings of the British Society Animal Science Conference, 8-10 April 2002*. BSAS, p. 132.

Mlambo, V. (2002). Modifying the nutritional effects of tannins present in *Acacia* and other tree fruits offered as

protein supplements to goats in Zimbabwe . PhD thesis, University of Reading.

Mlambo, V., Mould, F.L., Smith, T., Owen, E. and Mueller-Harvey, I. (2002). The use of wood ash to overcome detrimental effects of tannins on *in vitro* fermentation of tree fruits. In: *Responding to the increasing global demand for animal products; an international Conference organised by the British Society of Animal Science (BSAS), American Society of Animal Science and the Mexican Society of Animal production, 12-15 November 2002 at UADY Merida*. BSAS, pp.58-59.

Mlambo, V., Mould, F.L., Owen, E., Smith, T., Mueller-Harvey, I. and Sikosana, J.L.N. (2002). *Dichrostachys cinerea* pods as protein supplements for goats fed on hay-based diets. In: (eds. T. Smith, P.J. Buttery and E. Owen): *Strategies to relieve nutritional and health constraints in smallholder owned goats; Proceedings of the second Link Project Meeting, 8-10 January 2002, Sokoine University of Agriculture, Morogoro, Tanzania*. Natural Resources International Ltd., pp. 57-67.

Mlambo, V., Mould, F.L., Owen, E., Smith, T., Sikosana, J.L.N., Evason, D., Mueller-Harvey, I. (2002). *Dichrostachys cinerea* pods as a protein supplement for goats fed on hay based diets. In: El Hadrami, I. (editor). *Proceedings of the XXI International Conference on Polyphenols, Marrakech, Morocco, 9-12 September 2002. Polyphenols Communications 1: 221-222*.

Sikosana, J.L.N., Smith, T., Mlambo, V., Owen, E., Mueller-Harvey, I. and Mould, F. (2002). *Acacia* and other tree pods as dry season feed supplements for goats. In: (eds. T. Smith, P.J. Buttery and E. Owen): *Strategies to relieve nutritional and health constraints in smallholder owned goats; Proceedings of the second Link Project Meeting, 8-10 January 2002, Sokoine University of Agriculture, Morogoro, Tanzania*. Natural Resources International Ltd., pp. 69-75.

Sikosana, J.L.N., Maphosa, V., Smith, T., Owen, E. and Mueller-Harvey, I. (2002). Use of local browse tree pods as dry season supplements for goats in the south-west region of Zimbabwe. In: *Responding to the increasing global demand for animal products; an international Conference organised by the British Society of Animal Science (BSAS), American Society of Animal Science and the Mexican Society of Animal production, 12-15 November 2002 at UADY Merida*. BSAS, pp.193-195.

Mlambo, V., Sikosana, J.L.N., Smith, T., Owen, E., Mould, F.L. and Mueller-Harvey, I. (2004). 1. Alleviating seasonal nutrient fluctuations in semi-arid areas of Zimbabwe: potential for tree fruits as protein supplements for goats. In (eds. T. Smith, S.H. Godfrey, P.J. Buttery and E. Owen): *Proceedings of the third Link Project Meeting, 3-7 February 2003, at Embu, Kenya*. Natural resources International Ltd., pp. 128-138.

Sikosana, J.L.N., Smith, T., Mlambo, V., Owen, E., Mueller-Harvey, I. and Maphosa, V. (2004). Supplementation of on-farm goats using feed resources available in South-West Zimbabwe. In (eds. T. Smith, S.H. Godfrey, P.J. Buttery and E. Owen): *Proceedings of the third Link Project Meeting, 3-7 February 2003, at Embu, Kenya*. Natural resources International Ltd., pp. 139-144.

Frazier, R.A., Papadopoulou, A., Mueller-Harvey, I., Kisson, D. and Green, R.J. (2003) Probing protein-tannin interactions by isothermal titration microcalorimetry. *Journal of Agricultural and Food Chemistry*. 51: 5189-5195.

Mueller-Harvey, I., Frazier, R.A. and Green, R.J. (2004). Probing tannin-protein interactions by isothermal titration microcalorimetry. American Chemical Society, 4th Tannin Conference, Philadelphia, USA, 22-26 August 2004. Abstracts of Papers of the American Chemical Society 228, 109-CELL Part 1, Aug 22, 2004.

Mueller-Harvey, I., Frazier, R.A. and Green, R.J. (2004). Probing tannin-protein interactions by isothermal titration microcalorimetry. (A. Hoikkala, O. Soidinsalo, KI. Wähälä, eds.), 22nd *International Conference on Polyphenols*, Helsinki, Finland, 24-28 August 2004. *Polyphenols Communications* 463-464.

Mlambo, V., Smith, T., Owen, E., Mould, F.L., Sikosana, J.L.N. and Mueller-Harvey, I. (2004). Tanniferous *Dichrostachys cinerea* fruits do not require detoxification for goat nutrition: *in sacco* and *in vivo* evaluations. *Livestock Production Science* 90: 135-144.

Sikosana, J.L.N., Ncube, S., Smith, T., Maphosa, V. and Matanga, E. (2004). Effect of dry season supplementation on live-weight gains and carcass characteristics in indigenous Matabele goats raised under a semi-extensive system. Paper submitted to the International Goat Conference, South Africa (July 2004).

Mlambo, V., Sikosana, J.L.N., Mould, F.L., Smith, T., Owen, E., Mueller-Harvey, I. (2005). Investigating the potential utility of the goat's ruminal adaptation strategies to tannins present in *Acacia* and other tree fruits. In (T. Smith, S.H. Godfrey, E. Ssewanyana, P.J. Buttery and E. Owen, eds.): *Proceedings of the fourth Link Project Meeting, 15-19 November 2004 at Masaka, Uganda*. Natural Resources International Ltd., pp. 78-84.

Mueller-Harvey, I., Mlambo, V., Smith, T. (2005). Tannins in animal nutrition and health – implications for temperate and tropical feeds. University of York, 4-6 April 2005, *Proceedings British Society of Animal Science*, p. 72.

Sikosana, J.L.N., Maphosa, V., Mlambo, V., Mould, F.L., Smith, T., Owen, E., Mueller-Harvey, I., De Waal, H.O. (2005). Live weight gains and carcass characteristics of indigenous Matabele goats fed browse fruits. In (T. Smith, S.H. Godfrey, E. Ssewanyana, P.J. Buttery and E. Owen, eds.): *Proceedings of the fourth Link Project Meeting, 15-19 November 2004 at Masaka, Uganda*. Natural Resources International Ltd., pp. 72-76.

Smith, T., Mlambo, V., Sikosana, J.L.N.S., Maphosa, V., Mueller-Harvey, I. and Owen, E. (2005). *Dichrostachys cinerea* and *Acacia nilotica* fruits as dry season feed supplements for goats in a semi-arid environment: Summary of a DFID funded project in Zimbabwe. *Animal Feed Science and Technology* 122: 149-157.

Smith, T., Owen, E., Mueller-Harvey, I., Sikosana, J.L.N., Mlambo, V. (2005). Increasing the productivity of smallholder owned goats through supplementation with tree fruits. University of York, 4-6 Apr 2005 *Proceedings British Society of Animal Science*, p. 33.

Sikosana, J.L.N., Smith, T. Owen, E., Mueller-Harvey, I., Mlambo, V., DeWaal, H.O., Sisito, G. (2006). Treated *Acacia nilotica* fruits as a feed supplement for pregnant indigenous Matabele goats, of Zimbabwe, grazing during the dry season. In (T. Smith, A. Vatta, P.J. Buttery and E. Owen, eds.): *Proceedings of the fifth Link Project Meeting, 12-15 September 2005, at Everglades Hotel, Howick, South Africa*. Natural Resources International Ltd., available as a cd.

Mlambo, V., Mould, F. L., Sikosana, J.L.N., Smith, T., Owen, E., Mueller-Harvey, I. (2006) Evaluating the relationship between chemical composition and *in vitro* fermentation of tannin-rich tree fruits. *Animal Feed Science and Technology* (Submitted)

Mlambo, V., Sikosana, J.L.N., Mould, F. L., Smith, T., Owen, E., Mueller-Harvey, I. (2006) The effectiveness of adapted rumen fluid vs. PEG to ferment tannin-containing substrates *in vitro*. *Animal Feed Science and Technology*. (Published online on 7 August 2006)

Mueller-Harvey, I. (2006) Unravelling the conundrum of tannins in animal nutrition and health. *J. Sci. Food Agric.* 86, 2010-2037.

Mlambo, V., Smith, T., Owen, E., Mould, F.L., Sikosana, J.L.N. and Mueller-Harvey, I. Wood ash inactivates tannins in *Acacia nilotica* and *Dichrostachys cinerea* fruits: an *in vitro* evaluation. *Animal Feed Science and Technology* (accepted subject to modifications).

Mlambo, V., Smith, T., Owen, E., Mould, F.L., Sikosana, J.L.N. and Mueller-Harvey, I. Potential for detannification of *Acacia nilotica* and *Dichrostachys cinerea* fruits using alkalis: an *in vitro* evaluation. To be submitted to *Tropical Animal Health and Production Journal*.

Mueller-Harvey, I., Mlambo, V., Sikosana, J.L.N., Smith, T., Owen, E., Brown, R.H. Can octanol-water partition coefficients be used to predict tannin effects *in vivo*? Paper to be submitted to *Journal Agricultural and Food Chemistry* (*in prep*)

Internal Reports

[List of reports and dates. Please highlight in bold the outputs produced during the last financial quarter of the project]

Smith, T.(1998). Report of stakeholders meetings held in Zimbabwe.

Smith, T.(2000). Response to caveats to justify continuation of the project beyond March 2000.

Kindness, H., Sikosana, J., Mlambo, V. and Morton, J (1999). Socio-economic surveys of goat-keeping in Matobo and Bubi districts. NRI Report No. 2451.

Mlambo, V. (2000). Polyphenolic chemistry in relation to the nutritive value of *Acacia* and other tree pods fed to goats in semi-arid areas of Zimbabwe. A report submitted in partial fulfillment of the requirements for a transfer from higher degree by research to PhD, University of Reading.

Maphosa, V. (2001). The effect of doe milking and supplementation on kid growth and doe performance. Zimbabwe Open University (*3rd year dissertation*).

Shinda, B. (2001). Degradability of different browse pods for use in a semi-arid region of Zimbabwe. Zimbabwe Open University (*3rd year dissertation*).

Other Dissemination of Results

[Please highlight in bold the outputs produced during the last financial quarter of the project]

Sikosana, J.L.N. (2000). The potential of indigenous goats in Zimbabwe as milk producers. *Paper presented at a Workshop on small ruminant development in Southern Africa, Mangochi, Malawi, 31 July-4 August 2000.*

Mlambo, V. (2002). Tree pods/fruit as protein supplements for goats in smallholder semi-arid areas of Zimbabwe. A seminar presented in the Department of Agriculture, University of Reading, 28 February 2002.

Sikosana, J.L.N. (2002). Small stock management. National radio and television interviews (ZBC).

Sikosana, J.L.N. (2000-2003). Contribution of project outputs at Zimbabwe trade Fair (AREX/MRS stand).

J. L. N. Sikosana, B. R. Banstola, H. K. Shrestha, M. M. Hossain, R. H. Sarwer, J. Kabirizi and F. Ejobi The importance of indigenous tree fruits (pods) and foliage in goat diets (in press) (ZC0305)

FTR, R7424, Executive Summary

Can feeding locally available plant materials rich in tannins reduce parasitic burden in ruminants and hence improve their productivity?

The purpose of the project was to investigate the potential of controlling gastrointestinal parasitic infections in tropical small ruminants using plants high in tannins or extracts from them. The use of locally available natural resources as anthelmintics would provide a simple, cost effective and environmentally friendly method of reducing the extent of one of the major causes of production loss in small ruminants. The research activities were carried out in the UK and Tanzania and included both *in vitro* and *in vivo* experiments using different types of tannins against various species of gastrointestinal nematodes. The *in vitro* studies reduced the numbers of animals required for the experimental studies. A survey was carried out in Tanzania to identify browse plants containing high tannin concentrations. Seasonal variation was also monitored. The anthelmintic activity of species with the highest levels of condensed tannins was tested in feeding trials with sheep and goats. Only limited reductions in the extent of nematode infections were observed. Commercially available extracts of tanniferous plants (quebracho from Argentina and wattle readily available in Tanzania) were able to reduce the worm burden of sheep infected with intestinal parasites when given as oral drenches. The studies with wattle tannin were conducted under field conditions in Tanzania following initial sheep studies with quebracho tannin in the UK. Oral wattle tannin drenches did not markedly reduce the extent of nematode infection in goats.

Further studies are needed to make definitive conclusions regarding the potential of using tannins as an alternative to the expensive synthetic anthelmintics. The project provided quantitative data on the potential of using a readily available and environmentally sustainable method of reducing the worm burden of small livestock.

Findings from these studies were disseminated in various scientific conferences and workshops which took place in India, Tanzania, UK, Mexico, Kenya, Uganda, South Africa and Thailand. Refereed research papers were also produced. A Tanzanian PhD student was trained who has returned to Tanzania and is continuing in the field of the contribution of small-stock to resource poor communities. A manual on worm management in small ruminants kept under small scale systems and a technical brief to state veterinarians has been produced.

Publications:

Butter,N.L., Dawson,J.M., Wakelin,D. and Buttery,P.J. (2000) Effect of dietary tannin and protein concentration on nematode infection (*Trichostrongylus colubriformis*) in lambs. *Journal of Agricultural Science* 134, 89-99. (most of data from previous DFID project but completed during present project)

Max, R. A.; Dawson, J. M.; Wakelin, D.; Buttery, P. J.; Kimambo, A. E.; Kassuku A. A. and Mtenga, L.A. (2001) Effects of condensed tannins in quebracho extract drench on faecal egg output and worm burdens of sheep parasitized with *Haemonchus contortus*. *Proceedings of the 19th Tanzania Veterinary Association Scientific Conference*. December 3rd – 5th 2001, Arusha, Tanzania.

Max, R. A.; Wakelin, D.; Buttery, P. J.; Kimambo, A. E.; Kassuku A. A. and Mtenga, L.A. (2002) Potential of controlling intestinal parasitic infections in small ruminants (sheep and goats) with extracts of plants high in tannins in *In: Responding to increasing global demand for animal products in Programme and Summaries*. An International Conference organised by the British Society of Animal Science, American Society of Animal Science and Mexican Society of Animal Production at UADY, Merida, Mexico, 12-15 November, 2002, pp 114-115.

Max, R. A.; Dawson, J. M.; Wakelin, D.; Buttery, P. J.; Kimambo, A. E.; Kassuku A. A. and Mtenga, L.A. (2002) Effects of condensed tannin extracts on gastrointestinal nematodes of small ruminants. In Smith, T., Godfrey, S. H., Buttery, P.J. and Owen, E. (ed.). *Helping smallstock keepers enhance their livelihoods: improving management of smallholder owned sheep and goats utilising local resources'* *Proceedings of the second DFID Livestock Production Programme Link Project (R7798) Workshop for Smallstock Keepers*. Sokoine University of Agriculture, Morogoro, Tanzania, Tanzania 8-10 January 2002 Natural Resources International Ltd., Ayesford, Kent, UK

Max, R. A.; Buttery, P. J.; Kimambo, A. E.; Kassuku A. A. and Mtenga, L.A. (2004) The potential of controlling gastrointestinal parasitic infections in small ruminants using plants high in tannins or extracts from them. Smith, T. Godfrey, S.H., Buttery, P.J., Owen, E. (ed.). *The contribution of small ruminants in alleviating poverty: communicating messages from research: Proceedings of the third DFID Livestock Production Programme Link Project (R7798) workshop for small ruminant keepers*. Izaak Walton Inn, Embu, Kenya, 4-7 February 2003. Natural Resources International Ltd., Ayesford, Kent, UK,

Max, R.A., Kassuku, A. A., Kimambo, A. E Mtenga L. A. and Buttery P. J. (2005) The use of wattle tannin drenches to reduce naturally acquired nematode infestations in a flock of tropical Black Head Persian sheep. In *Integrating livestock-crop systems to meet the challenges of globalisation* (edited by P. Rawlinson, C. Wachirapakorn, P. Pakdee and M. Wanapat). *Proceedings of the Animal Husbandry Association of Thailand and British Society of Animal Science International Conference, Khon Kaen, Thailand, 14-18 November, 2005, Volume 2, T114*

Max, R. A.; Kimambo, A. E.; Kassuku A. A.; Mtenga, L.A. and Buttery, P. J (2005) Tannins: An environmentally friendly method of controlling intestinal parasites in the tropics and subtropics? *Proceedings of the British Society of Animal Science (BSAS)*. (2005) p30

Max, R. A.; Kimambo, A. E.; Kassuku A. A.; Mtenga, L.A. and Buttery, P. J (2005) The effect of wattle tannin drench or an acacia meal supplement on faecal egg counts and total worm burdens of tropical sheep with experimental nematode infection. In Smith, T., Godfrey, S.H., Buttery, P.J., Ssewanyana, E. and Owen, E. (ed.). Small stock in development Proceedings of a workshop on enhancing the contribution of small livestock to the livelihoods of resource-poor communities. Hotel Brovad, Masaka, Uganda, 15-19 November 2004. Natural Resources Ltd., Aylesford, Kent.

Max, R.A., Wakelin, D., Dawson, J.M., Kimambo, A.E., Kassuku, A.A., Mtenga, L.A. Craigon, J. and Buttery, P.J. (2005) Effect of quebracho tannin on faecal egg counts, worm burdens of temperate sheep with challenge nematode infections. *Journal of Agricultural Science* 143:519-527

Max, R.A., Wakelin, D., Dawson, J.M., Kimambo, A.E., Kassuku, A.A., Mtenga, L.A. Craigon, J. and Buttery, P.J (2005) Effect of two commercial preparations of condensed tannins on the survival of gastrointestinal nematodes of mice and goats *in vitro*. *South African Journal of Animal Science*:35 213-220,

Max, R.A. Kimambo, A. E. Kassuku, A. A. Mtenga L. A. and Buttery P. J. (2006) The use of wattle tannin drenches to reduce naturally acquired nematode infestations in a flock of tropical Black Head Persian (BHP) sheep. in 'Making a difference: improving the livelihoods of resource-poor small stock keepers'. Smith, T., Godfrey, S.H., Buttery, P.J., Vatta, A and Owen, E. (ed.). Proceedings of a workshop 'Improving The Well-Being of Resource-Poor Communities – The Role of Small Livestock' in Howick South Africa between 12th to 15th September. 15-19 November 2005. Natural Resources Ltd., Aylesford, Kent. (in press).

There are 2 further drafted publications to be submitted to refereed journals. This will be undertaken by the project team.

Other dissemination materials

Oral communication to Scientific workshop on "Participatory research on goat feeding systems and silvi-pastoral development on common lands in Northwest India". September, 11th - 13th 2000, Udaipur, India.

Smith, T. (2000) Use of tanniferous feeds to improve smallholder goat production: Project to link R7424 (Tanzania), R7351 (Zimbabwe) and R6953 (India) to increase dissemination, outputs and impact. Oral Presentation. 3rd Livestock Production Workshop, Ingwe Lodge, Matobo, Zimbabwe. 24-26 September 2000.

Max, R. A. (2003) The potential of controlling gastrointestinal nematodes in tropical small ruminants with tannins. PhD thesis. University of Nottingham, England.

Max, R.A. (2005) A plant-based treatment for roundworms? In "Communicating science for sustainable development". September 2005 edition, <http://www.agfax.net>. An AGFAX radio interview by WREN Media, UK. (Radio interview)

Max, R.M.¹, Jayaswal, M.L.², Vatta, A³, Kassuku, A.A.¹, Kimambo, A.E.¹ and Mtenga, L.A.¹ (2006) "A Technical Manual for Worm Management in Small Ruminants" ¹Sokoine University of Agriculture, Morogoro, Tanzania; ²New Era, Kathmandu, Nepal; ³Onderstepoort Veterinary Institute (OVI), South Africa. (ZC0304).

Annex D References

Gill, H.S. and Le Jambre, L.F. (1996) Preface- Novel approaches to the control of helminth parasites of livestock. *International Journal for Parasitology* 26, 797 – 798.

Hammond, J.A.; Fielding, D. and Bishop, S.C. (1997) Prospects for plant anthelmintics in tropical veterinary medicine. *Veterinary Research Communications* 21, 213 – 228.

Holness, D. (Ed.) (1988). *Beef production manual*. Cattle Producers' Association, Harare, Zimbabwe.

Malan, F.S.; van Wyk, J.A and Wessels, C. D. (2001) Clinical evaluation of anaemia in sheep: early trials. *Ondestepoort Journal of Veterinary Research* 68, 165 – 174.

Ministry of Livestock Development (MLD). 2006. *National Livestock Policy (Final Draft), May 2006*. The United Republic of Tanzania, Ministry of Livestock Development.

Ministry of Livestock and Fisheries Development (MF&LD). 2006a. *Draft National Livestock Policy. By the Technical Working Group*. Republic of Kenya, Ministry of Livestock and Fisheries Development, February 2006.

Ministry of Livestock and Fisheries Development (MF&LD). 2006b. *Draft Dairy Policy 2006. Towards a Competitive and Sustainable Dairy Industry for Economic Growth in the 21st Century and beyond*. Republic of Kenya, Ministry of Livestock and Fisheries Development, March 2006.

Mozambique:

Livestock Development Strategy (1997)

Livestock development Policy (revised draft 92004)

Action Plan for the Reduction of Absolute poverty (PARPA 1 [2000]; PARPA 11 [2006]).

Mtengeti et al. (2004). Forage production, conservation and utilisation. *Research dissemination series, Volume 2 of TARP II SUA Project SUA:Sokoine Univ Agric*.

Mtengeti, E.J., Mo, M., Mtenga, L.A., Phiri, E.J., Urrio, N.A., Pereka, A., Laswai, G.H., Chibunda, R., Mgassa, M., Mbwile, R., Israeli, S., Mwakilembe, A. and Ayo, E. (2005). Performance of some multipurpose trees under smallholder dairy farmers home garden plots in Tanzania. Report tarp in Tanzania Regional Conference, pp.218-233, <http://www.bunda.unima.mw/report.pdf>.

Niezen, J.H.; Waghorn, T.S.; Waghorn, G.C. And Charleston, W.A.G. (1993) Internal parasites and lamb production - a role for plants containing condensed tannins? *Proceedings of the New Zealand Society of Animal Production* 53, 235 – 238.

Owen, E., Kitalyi, A., Jayasuriya, N. and Smith, T. (Ed.)(2005). *Livestock and wealth creation; improving the husbandry of animals kept by resource-poor people in developing countries*. Nottingham University Press, Nottingham, UK.

Perry, B. D., Randolph, T. F., McDermott, J. J., Sones, K. R. & Thomson, P. K. 2002. Investing in animal health research to alleviate poverty. ILRI (International Livestock Research Institute), Nairobi, Kenya, 148 pp. ISBN 9291461083.

Prichard, R.K. (1994) Anthelmintic resistance. *Veterinary Parasitology* 54, 259 – 268.

Smith, T. and Wangiri, E.O. (Ed.) (1996). *Desertification control and natural resource management; case studies from SADC countries*. United Nations Educational and Scientific Organization (UNESCO), Dakar, Senegal.

van Wyk, J.A., Malan, F.S. and Bath, G.F. (1997) Rampant Anthelmintic Resistance in Sheep in South Africa – What are the Options? In: *Managing Anthelmintic Resistance in Endoparasites* (Eds. J.A. van Wyk and P.C. van Schalkwyk). Workshop held at the 16th International Conference of the WAAVP, pp. 51 – 63. Sun City, South Africa.

Wangiri, E.O. (1996). Desertification and environmental degradation; background to the problems within Africa. In (Smith, T. and Wangiri, E.O., ed.); *Desertification control and natural resource management; case studies from SADC countries*. United Nations Educational and Scientific Organization (UNESCO), Dakar, Senegal.
