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INTRODUCTION

In the Darwin Katherine region there was a good opening to the monsoon season in December but very little rain in January. February and March were wet but the season then ended somewhat abruptly. The dry weather in January delayed the planting of crops and some of these were still filling grain when the rains ended. Nevertheless crop yields were average to good overall with some very good crops of sorghum being grown, largely by reduced or zero till practices.

The season in the Katherine region was a good one for the pastoral areas with somewhat above average rainfall in the Victoria River District which gave relief to stations in the southern VRD in particular after two seasons of below average rainfall.

On the Barkly Tablelands the latter part of 1993 was quite a good season but the first half of 1994 ranged from poor in the central region to quite good on the western stations.

Winter was mild in Central Australia, with frosts in early July 1993. Limited rain was recorded in all areas of the Alice Springs District from September 1993 to February 1994. In south east areas generally less than 30 mm was recorded each month but, apart from localised rain south west of Alice Springs in June 1994, no further large falls of useful rain were recorded. In north west areas more than 50 mm was recorded in some months.

Cattle movement has been affected by the drought in Queensland and drought has also affected southern Territory properties. In the north prices were supported by the still expanding live export trade. The trade found difficulty in 1993-94 in filling orders for SE Asia from the northern areas of the Territory and export of Alice Springs District cattle to South East Asian markets was initiated in March 1994. The British and European breeds of cattle from the southern parts of the Territory do not thrive in lowland feedlots in SE Asia, and Bos indicus types are preferred, but southern cattle are suitable for highland feedlots or immediate slaughter.

Due to drought conditions in Queensland at the end of 1993, large numbers of Barkly Tablelands cattle were trucked through Alice Springs to South Australia.

A total of 66 322 cattle left the NT from the Bohning Cattle yards in Alice Springs during 1993. Cattle inspected through the Bohning Cattle Yards, Alice Springs in 1993-94, totalled 57 296 head. According to 1992/93 records, this is believed to be 30-50% of the total Alice Springs District turnoff.

Interest in buffalo from southern states has continued and substantial herds are now established, particularly in Western Australia. Brunei has taken 1200 slaughter animals and the Tender-Buff trade took 250 animals which was all that could be supplied. Interest has grown in the utililisation of camels for meat and leather products and the farmed crocodile industry has continued to expand.

The value of the horticultural product of the Territory increased by about 20% with nursery returns contributing half of the increase. There were minor increases in mangoes and melons but a 25% fall in the value of bananas. Prices for mango, the largest crop, remained steady. The spread of Thrips palmi to Queensland caused a lifting of quarantine restrictions to that state.

The commercial fishery season was above average for catches for most fish species except mackerel and crabs also yielded well. There was a very poor start to the 1994 banana prawn season but tiger prawns gave reasonable yields. Although the wet season rainfall was no more than average the recruitment of young barmmbundi was unusually high. This may indicate that rainfall in the catchment of some of the northern river systems was higher than was shown by recordings in the limited number of coastal weather stations.

The Department was totally reorganised before the start of the year with the technical areas now being covered by nine Divisions, Fisheries, Horticulture, Animal Health, Agriculture, Resource Protection, Land Resource Management and three Pastoral Divisions, Katherine, Tennant Creek and Alice Springs. This year's Technical Annual Report reflects this new structure but retains the format of reporting Projects, in some cases grouped into Programs. Many Projects are a continuation of ones reported last year.
FISHERIES DIVISION

FISHERIES RESEARCH AND DEVELOPMENT BRANCH

PROGRAM: MARINE FISH RESEARCH

- Assessment of Demersal Fish Stocks

Project Period: 1989 ongoing
Project Officers: D Ramm, J Lloyd and A Coleman
Project Location: Darwin

Objectives:

- Maintain a comprehensive catch and effort database for demersal finfish fisheries in northern waters.
- Examine catch and effort trends in demersal finfish fisheries in northern waters.
- Obtain information on the biology and population parameters of *Lutjanus* spp and *Pristipomoides* spp in waters between 127-137°E.
- Model population dynamics and assess stocks of *Pristipomoides multidens* and *Lutjanus malabaricus*.
- Refine fishery models and review stock assessments.

Background:

Assessments of stocks require a sound understanding of trends in catch and effort, and knowledge of the distribution, abundance and biology of species under investigation. Fishery-dependent data (e.g., catch and effort) provide good estimates of distributions and abundance over the fishing grounds; however, there are large uncertainties with the extrapolation of this data beyond the areas fished. These uncertainties are confounded in developing fisheries, such as those operating in the Timor Box, where erratic fishing occurs. This project provides fundamental information required for stock assessment and management plans.

Method:

Development and maintenance of research logbooks and onboard collections of fishery data.

Undertaking laboratory studies on age, growth and reproduction of *Lutjanus* spp and *Pristipomoides* spp.

Results:

Daily research logs were developed for all marine fisheries. These logs were issued to fishermen on a voluntary basis. Problems with the logs were noted, and logs modified accordingly. The voluntary scheme provided a good coverage of the trap and dropline fishery in the Timor Box. The structure of the catch and effort database was reviewed and refined.

The project has provided valuable data on Catch Per Unit Effort (CPUE) and biomasses of major species of fish in the Timor and Arafura Seas between 127-137°E. This data, and information on herding and escapement, have provided managers with the first fishery-independent estimate of yield for *L. malabaricus* in this region. Prior estimates of yield, based on logbook and observer data, are presently considered less reliable than those derived from survey data (Northern Fisheries Assessment Working Group Report 1992).

Conservative annual yields for red snapper, based on present knowledge, are 600 t per year in the Timor Sea, 1 300 t per year in the Timor Box, 3 900 t per year in the Arafura Sea and 4 100 t per year in the Gulf of Carpentaria, leading to an overall yield estimate of about 10 500 t per year for northern Australian waters (assuming a yield of approximately 600 t per year on the Northwest Shelf).

Conservative annual yields for goldband snapper, based on present knowledge, are 100 t per year in the Timor Sea, 400 t per year in the Timor Box and 100 t per year in the Arafura Sea, leading to an overall yield estimate
of about 700 t per year in northern Australian waters (assuming a combined yield of less than 100 t per year for the Northwest Shelf and Gulf of Carpentaria).

Historically, snappers were exploited at levels close to these annual yields, with trawl catches of red snapper up to 5 400 t per year in 1989, and goldband snapper up to 900 t per year in 1984. Departure of foreign trawlers at the end of 1990 has resulted in a marked decrease in catches of red snapper (<1 000 t per year). However, catches of goldband snapper have remained relatively high (400 t per year) due to developments in the domestic trap and dropline fishery.

Determination of allowable catches for snappers in northern demersal fisheries, including trap and dropline, will require further dialogue between industry and fishery managers, and clear identification of management objectives (eg maximise yield, maximise profit, maximise employment or maximise conservation).

Ms Lloyd is undertaking an external MSc thesis at the Northern Territory University and her project is entitled: "Biology of Pristipomoides multidens and P. typus in the Timor and Arafura Seas". Ms Coleman is undertaking an external PhD thesis at James Cook University and her project is entitled: "A comparison of the life histories and distributions of Lutjanus malabaricus, L. erythropterus, L. sebae and L. timorensis in northern waters".

PROGRAM: BARRAMUNDI RESEARCH

***** Barramundi Population Assessment

<table>
<thead>
<tr>
<th>Project Period</th>
<th>1978 ongoing</th>
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<tbody>
<tr>
<td>Project Officer</td>
<td>R Griffin</td>
</tr>
<tr>
<td>Project Location</td>
<td>Darwin/NT Rivers</td>
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</table>

**Objectives:**

- Provide long-term, fishery independent assessment of the status of barramundi stocks in critical areas such as the Mary and Daly rivers, utilising a range of methods;
- Assess the level of recruitment of barramundi (spawning success) from year to year and evaluate fluctuations due to seasonal factors and environmental changes;
- Monitor and assess the impact of vegetation and drainage changes in the Mary River, particularly in relation to the saline intrusion control barrage at Shady Camp. This aspect is clearly linked to the first objective.

**Background:**

Regular sampling, mainly using gillnets, castnets and electrofishing, is conducted at several locations, mainly on the Mary River, concentrating on the billabong environment where populations are isolated and relatively stable, at least during the dry season. Since 1982 regular sampling of juvenile upstream migrants has been undertaken at Bamboo Creek and Daly River Crossing to assess interannual changes in abundance. Current recruitment monitoring is concentrated in the Mary River. Barramundi sampled are measured and examined for signs of disease, scales are removed for aging and the fish is then usually tagged and released.

**Method:**

A major feature of this work in the past seven years has been development of a technique known as a Closed Area Depletion Experiment (BARRACADE). This involves virtual total sampling of a section of billabong, some 400 m in length, over a period of seven days. The sampling area is isolated from the rest of the billabong by small mesh, heavy gauge block nets which prevent fish from entering or leaving the area unassisted. The fish are caught using gillnets ranging in mesh size from 75 mm to 180 mm. This range of mesh sizes effectively samples the whole population of barramundi in the billabong environment. After measurement, scale sampling and examination, the fish are tagged and released outside the enclosed area. This technique provides an estimate of the population of the sample area and an accurate assessment of the age structure of that population.

A BARRACADE sampling operation was conducted at Yellow Water Billabong in Kakadu National Park with funding from ANCA.
Regular monitoring of environmental conditions is undertaken at Corroboree Billabong and Shady Camp. Video film and photographs are taken to document the growth of aquatic vegetation and other habitat changes.

Results:
Results to date indicate a substantial recovery in barramundi populations in the Mary River. Very strong year classes from spawning in 1983/84, 88/89, 90/91 and 92/93 have been identified. This spawning success relates directly to the extent of wet season rainfall. Conversely, very poor year classes have resulted from the very dry spawning seasons of 89/90 and 91/92. The age structure of the population at Yellow Water was also dominated by 2 age classes (91/92 and 92/93) and the proportion of the 2 year olds (ie 91/92) was much higher, probably due to a very low incidence of the "red spot" ulcer disease which was prevalent at Corroboree. Considerable progress has been made with development of a "delay difference" type computer model of the barramundi fishery.

Recreational Barramundi Fishery Assessment

- Project Period: 1978 ongoing
- Project Officer: R Griffin
- Project Location: Darwin/NT Rivers

Background:
Recreational fishing, of which barramundi fishing is a very substantial part, is of major economic and social importance to the northern Territory. Data on which to base assessment of the impact of recreational fishing is essential for management of the barramundi resource. In the absence of a catch and effort reporting system, such as applies to the commercial fishery, the information must be collected directly. In areas where commercial fishing has been excluded in recent years there is a need to replace the catch and effort data derived from the commercial fishery for stock assessment purposes.

Methods:
This data was collected by surveys of anglers in the field (creel surveys) and at roadside interviews of anglers on the Arnhem Highway at Humpty Doo. The roadside surveys are conducted on May Day and Picnic Day weekends every year. Survey effort is concentrated on critical areas such as the Mary River and the Daly River.

Results:
Data in recent years has shown a levelling off in the rate of growth of recreational barramundi fishing in the Mary River. Excellent fishing in the Shady Camp area during the late wet season and early dry season in recent years has resulted in seasonally high fishing effort at that location.

The effectiveness of the regulations in limiting the impact of recreational fishing on the resource is shown in the difference between the total catch rate and the harvest (or take home) catch rate. The total catch rate in the Mary River has increased substantially, reflecting increased abundance, while the harvest rate has not increased. The size of fish taken in the Mary River has increased substantially.

PROGRAM: PRAWN MONITORING

- Northern Prawn Fishery Monitoring

- Project Period: 1978 ongoing
- Project Officer: R Buckworth
- Project Location: Darwin

Objectives:
To maintain a watching brief on the Northern Prawn Fishery (NPF) for issues of specific interest to the Northern Territory.
Background:
One of Australia’s most valuable fisheries, the NPF accounts for up to 50% of commercial fisheries production (landings) from waters off the NT. The Commonwealth is responsible for the fishery’s management but NT input is through the fishery’s management advisory committee. It is also necessary that the interactions of the NPF with other NT fisheries and communities is monitored.

Method:
Maintain access to the NPF logbook system and liaise with the logbook collection service and industry. Maintain data bases of information collected under previous studies.

<table>
<thead>
<tr>
<th><strong>Assessment of the Feasibility of Trapping Prawns</strong></th>
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<tr>
<td><strong>Project period:</strong> 1991 to 1993</td>
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<tr>
<td><strong>Project Officer:</strong> R Buckworth</td>
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<tr>
<td><strong>Project Location:</strong> Darwin and western Gulf of Carpentaria</td>
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</tbody>
</table>

Objectives:
- Establish the technological feasibility of prawn trapping.
- Evaluate the economies of prawn trapping as an additional fishing method for Australia’s prawn fisheries.

Background:
An economic appraisal (Buckworth and Cann 1992) indicated that prawn trapping could be economically feasible at catch levels much lower than for trawling. A passive fishing method such as trapping would be environmentally benign, and produce a maximum quality product. It would provide an additional option in resource management strategies. However, there has previously been little scientific appraisal of the method.

Additional funding for the program during 1992-93 was provided by the Fisheries Research and Development Corporation ($56300) and the Department of Primary Industries and Energy ($6444).

The program was conducted in four separate sections:
- An economic model to provide a preliminary assessment of whether the project should be addressed and as a framework for eventual commercial feasibility analysis;
- Pilot studies in the Groote Eylandt area (August 1992) included sets of several trap designs and baits;
- Observations of behaviour of prawns in aquaria and ponds with respect to traps and baits; and
- Comparative trawling and trapping experiments.

Method:
Preliminary economic modelling was based on the performance of trawlers currently in the fishery and on vessels operating with similar logistic constraints to a proposed trapping operation. Sensitivity of results to the various assumptions were evaluated.

Observations were made of prawns in aquaria and ponds, testing whether the prawns would respond to a range of baits, enter various trap types and whether they could escape from various trap types.

In both pilot and extensive field trials, varieties of baits and trap designs were set near trawl grounds.

Results:
Although prawns were readily captured in traps in aquaria and aquaculture ponds, very few were taken in field
trials. It was concluded that the method would not be economical without considerable research input.

PROGRAM: SPANISH MACKEREL RESEARCH

♦ ♦ ♦ Troll Fishery for Spanish Mackerel

<table>
<thead>
<tr>
<th>Project Period</th>
<th>1991 ongoing</th>
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<tbody>
<tr>
<td>Project Officers</td>
<td>R Buckworth, N Gill</td>
</tr>
<tr>
<td>Project Location</td>
<td>Darwin</td>
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</tbody>
</table>

Objectives:
- Identify the sectors of the fishing industry exploiting mackerel, their target species, and fishing unit characteristics;
- Develop a logbook and biological monitoring system for the provision of both commercial catch and effort data, and biological data;
- Identify the geographic structure of stocks of the target species; and
- Draw together all available information, develop models of the fishery which allow stock assessment and exploration of different management regimes, and indicate required research.

Background:
Participation in the troll mackerel fishery has been limited in response to concern from fishermen and management alike that an increase in the level of fishing on mackerel stocks could reduce economic viability of operators and lead to over-exploitation. A CSIRO analysis of Taiwanese fishing operations in the Australian Fishing Zone indicated that the stock may have been over-exploited. Local participation in the troll fishery grew through the mid 1980s and peaked in 1990 at about 270 t. A research program to establish the parameters of the fished stock is thus highly desirable.

Method:
Sex, length and reproductive information are collected by DPIF staff on board fishing vessels, and by selected fishermen. Computer stock assessment models are being developed that include information from catch returns and the literature, and use biological data on size, sex and age composition and reproductive state to construct and test the models.

Results:
Sex, length and reproductive information have now been collected for about 5000 fish, which exceeds 10% of the catch over the study period. Otoliths for age distribution estimation have been collected from about half of these. Several model structures have been developed, with the collaboration of WA Fisheries staff but information included in them is not yet adequate to indicate the extent of the mackerel stock. The models are being used to identify research direction.

♦ ♦ ♦ The Age Structure of NT Spanish Mackerel Catches

<table>
<thead>
<tr>
<th>Project Period</th>
<th>March 1994-Oct 1994</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Officer</td>
<td>R Buckworth</td>
</tr>
<tr>
<td>Project Location</td>
<td>Darwin</td>
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</tbody>
</table>

Objectives:
- Provide an estimated age structure for catches in the NT troll mackerel fishery for the 1991 to 1993
fishing seasons, for extension of population assessment to include an age-structured model.

Verify the growth relationships currently in use for stock assessment, or provide the information from which a new relationship might be developed.

Background:
Otoliths, small bony structures found within the inner ear of fishes, may be used to ascertain the age of fish. The age structure of a fished population gives information on rates of growth and death, and can therefore be a source of information for use in population modelling.

The Fisheries Research and Development Corporation pro-active fund has provided $18000 for this project.

Method:
Annual marks on otoliths, derived from the project on the troll fishery, are counted from both whole specimens and mounted sections.

The age of a substantial sample of the catch is thus ascertained, and by raising estimates with length frequency and catch return data, the age structure of the fished population is predicted.

Results:
All otoliths collected during 1991-1993 have been examined whole, have been sectioned and most sections have been examined and data entered. Analysis is under way.

PROGRAM: STOCK ASSESSMENT

Fishery Stock Assessment Program

Project period: 1992 ongoing
Project Officers: R Buckworth, D Ramm
Project Location: Darwin

Objectives:

- Develop the stock assessment competence of Fisheries Division staff.
- Ensure that the best assessments available are used in the management of Northern Territory fishery stocks.
- Use stock assessments to evaluate and direct Fisheries Research and Development and Fisheries Management Programs.
- Document and publish the material used in Northern Territory stock assessments.
- Seek opportunities to enlist external expertise both in the assessment process and as peer review, by liaising with other workers and institutions with expertise in stock assessment or related disciplines. In this way, a network of individuals and institutions that can jointly improve the quality of Australian tropical fisheries stock assessment will be developed.
- Develop the Northern Territory’s Fisheries Division as a centre of expertise in tropical fish stock assessment.
- Promote understanding of the principles and information needs, and the interpretation and application of stock assessment programs among client groups.

Background:
Fishery stock assessment is at the core of most R&D programs within the Division. This program aims, by
providing coordination, evaluation and drawing in expertise, to improve the development and application of stock assessments within the Fisheries Division. Ancillary aims include the concomitant development of expertise in stock assessment techniques and communication with client groups.

Training and model development were given a considerable boost during 1992 with FRDC-funded workshops.

Method:
The stock assessment framework of the Territory’s commercial fisheries are to be examined in turn - the models used, the data upon which they were based, current information needs and research directions and the management background will be examined. Documentation of the stock assessments will be encouraged. There will be appraisal of the alternative approaches and opportunistic use is made of interstate experts. Mr Norm Hall of Western Australia Fisheries has already assisted in this respect.

PROGRAM: MUD CRAB RESEARCH  

Mud Crab Research  

Project Period : 1990 ongoing  
Project Officer : I Knuckey  
Project Location: Darwin  

Objectives:
Conduct research to provide biological information on the Northern Territory mud crab (*Scylla serrata*) resource. Such information should assist in the development of management decisions that ensure the long-term viability of the resource and its ability to sustain a commercial and recreational fishery.

Background:
During 1993, commercial fishermen caught over 225 tonnes of mud crabs, a record for the NT fishery. This resulted from extremely good fishing in the south-west region of the Gulf of Carpentaria. Although commercial fishing is ultimately capped by licence and pot restrictions, there is increasing effort being directed into the mud crab fishery as these licences are worked harder and for more months of the year and recreational fishing increases. This development warrants thorough research into the population biology of mud crabs to ensure the stocks are not overfished. We are assessing the status of mud crab stocks in the NT and monitoring of the effect of fishing.

Method:

- Fisheries research officers continued to collect biological data from the catches of commercial fishermen at major crabbing regions. The sex, width, weight, moult stage, growth phase, damage and maturity of the crabs were recorded;
- Methods of sampling of juvenile crabs before they are recruited to the fishery have proved unsuccessful but trials of different methods are being continued;
- Monthly examination of the gonad condition and egg development of mature females is completed;
- Tagging of mud crabs for estimates of growth is feasible and a tagging program is operating in some commercial fishing areas.

Results:

- Information on the size at maturity of mud crabs in the Northern Territory has highlighted possible advantages of raising the minimum legal size limit from 130 to 140 mm. These size limit changes may be introduced throughout the fishery in 1995.
- A study on a parasite which causes mud crab sterility has shown that levels of infection are relatively low. Commercial fishermen are monitoring infection levels and recording the information in their logbooks.
Increasing annual catches reflect increasing effort being directed into the fishery. Overall, the stocks appear healthy but evidence of local depletions are apparent. A conceptual model of the NT mud crab fishery is being developed based on catch and effort data and the biological data already collected.

Juvenile mud crabs have been caught within months of settlement but total numbers are still low.

Annual cycles in female reproduction are apparent after analysis of gonad condition.

Tagging of juvenile mud crabs is complete and useful growth information has been gained.

PROGRAM: PEARL OYSTER RESEARCH

+++ Pearl Oyster Research

**Project Period**: 1990 ongoing (FRDC 1994)

**Project Officer**: I Knuckey

**Project Location**: Darwin

**Objective**: Conduct research to provide biological information on the Northern Territory pearl oyster (*Pinctada maxima*) resource. Such information should assist in the development of management decisions that ensure the long-term viability of the resource and its ability to sustain a commercial fishery.

**Background**: Since the late 1800s, NT pearl oyster stocks have been extensively fished for use as mother-of-pearl (MOP). Overfishing of pearl oyster beds has occurred on numerous occasions, as evidenced by extreme fluctuations of catch and effort. The fishery declined significantly in the early 1960s when the invention of plastics reduced demand for MOP. By this time however, pearl culture techniques were developing and today, the cultured pearl industry in Australia is worth over $100 million annually. This industry is still based primarily on oysters collected from wild stocks, so, with a history of overfishing, and the general lack of information regarding pearl oyster stocks in the NT, careful monitoring of pearl oyster stocks must be maintained. Consequently, since 1988 strict management controls have been in force, and research on the population biology and status of the stocks is being undertaken.

**Method**:
- NT DPIF and the Fishing Research and Development Corporation have undertaken research to monitor the commercial catch of pearl oysters around the NT.
- NT DPIF and Bureau of Resources Sciences are working together to use historical catch and effort information to assess the status of the NT pearl oyster stocks.
- Spat collectors have been deployed near the commercial pearl oyster grounds to determine spawning and recruitment patterns.

**Results**:
- Information gathered from commercial catches has enabled accurate determination of length frequency and morphology of pearl oyster used for MOP and culture.
- A biomass dynamic model based on historical catch and effort data is providing biomass estimates of the NT pearl oyster beds.
- Only a small number of pearl oysters were observed on the spat collectors. Information on their settlement and abundance, and those of other bivalve species has been collected.
PROGRAM: SHARK

♦♦♦ Shark Fisheries Assessment

- Project Period: 1991 onwards
- Project Officer: R Slack-Smith
- Project Location: Darwin

Objectives:
To collate all available information on the shark fishery off northern Australia and to reassess stocks and their levels of actual and potential exploitation.

Results:
An application to FRDC to provide funding for a contract officer to carry out the necessary data consolidation and analyses was rejected. Alternative arrangements are being sought.

PROGRAM: FISHING GEAR TECHNOLOGY RESEARCH

♦♦♦ Effects of Trawl Design on By-catch and Benthos in Prawn and Fin-fish Fisheries

- Project Period: 1 July 1994 to 1 February 1996
- Project Officer: R Mounsey
- Project Location: Northern Territory/Queensland/Tasmania

Objectives:
The objectives of this large program are to:
- develop mechanisms to enhance bycatch survival and reduce trawl by-catch;
- measure and reduce the impact of trawls on the benthos;
- study fish behaviour and survival of by-catch from standard and modified trawls.

The project is being undertaken by DPIF, CSIRO and AMC. Net trials were conducted off Tasmania on board the RV Reviresco. Further trials are planned using the FRV Southern Surveyor. FRDC is providing the majority of the funding for this project.

♦♦♦ Non-Trawl Capture Methods for Snapper

- Project Period: 1993 - 1995
- Project Officer: R Mounsey
- Project Location: Darwin/NT Trawl Grounds

Objectives:
To develop alternative methods (ie traps, longlines, etc) of fish capture on NT trawl grounds.

Background:
Funding for this project is being sought from the FRDC Proactive Fund.

While trapping of fish is not new, collapsible trap designs are being developed as an alternative to trawling in the offshore areas. It is envisaged that the traps will be set in lines. Drop lining techniques are also to be tested.

Progress to Date:
Several prototypes traps have been made and tested.
Less Destructive/More Efficient Prawn Trawls Extension

Objectives:
To develop a new trawl design and techniques that:

- Significantly reduces non-commercial bycatch (including turtles and fish);
- Retains prawn catching ability at least equal to existing trawls;
- Improves the quality of landed prawns;
- Reduces catch sorting time; and,
- Improves the commercial viability of prawn vessels.

Background:
The project was planned during the latter part of 1991 and commenced in 1992. Support was obtained from the Queensland DPI, the Australian Fisheries Service and CSIRO. The QDPI Fisheries Branch became actively involved in the project which received significant funding from the former Australian Fisheries Service.

Results:
The project has now entered the final phase where commercial testing and extension are being carried out, principally off Queensland.

Tropical Fisheries Technology Centre

Objectives:
To investigate the benefits of establishing a national/international tropical fisheries technology centre in northern Australia to cover the Indo-Pacific region. Such a centre ('Fish Tec') would address the following issues associated with present harvesting techniques:

- marine environment
- resource management
- resource development
- biological sampling
- social, economic factors, and,
- wildlife

Progress:
A prefeasibility study on FishTEC was carried out by SCP Fisheries Pty Ltd in early 1994. The report from this study recommended that a full feasibility study should be undertaken. External funding was sought for the full feasibility study but to date no positive results have been obtained.
AQUACULTURE BRANCH

🌟🌟🌟 Extensive Rearing of Barramundi Larvae

<table>
<thead>
<tr>
<th>Project Period</th>
<th>1993-1994</th>
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<tbody>
<tr>
<td>Project Officer</td>
<td>Chris Kuo, Glenn Schipp</td>
</tr>
<tr>
<td>Project Location</td>
<td>Darwin Aquaculture Centre</td>
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</tbody>
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Objective:
To lower the cost of fingerling production through the use of extensive culture.

Background:
Extensive rearing or green water production of marine fish larvae involves stocking the larvae into specially prepared marine ponds that have been fertilised to encourage a plankton bloom. The advantages of this method are the significant savings in labour and the production of better quality fish when compared to intensive, hatchery reared fish.

The techniques for green water production have been progressively passed on to Northern Territory barramundi farmers over the last two years.

Results:
During 1993/94 all barramundi farmers were able to produce fingerlings using the green water method. Although some failures were reported, the method was generally considered to be a success. Experiments for green water production have been concluded and support will continue to be given to the farmers in the form of technical advice and assistance with solving problems if and when they occur.

🌟🌟🌟 Intensive Rearing of Mudcrabs

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<tr>
<th>Project Period</th>
<th>1993-1994</th>
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<tbody>
<tr>
<td>Project Officer</td>
<td>Chris Kuo</td>
</tr>
<tr>
<td>Project Location</td>
<td>Darwin Aquaculture Centre</td>
</tr>
</tbody>
</table>

Objective:
To examine the feasibility of the commercial production of mud crabs for marine aquaculture farms.

Background:
Mud crab aquaculture is an economically important industry in many south east Asian countries. Juvenile crabs for culture are obtained from wild fisheries. Their capture represents severe ecological and logistical problems. Techniques for the mass production of juvenile crabs have not been established so the industry remains dependent on wild stocks. Intensive, semi-intensive and extensive larval rearing systems, based on those used for prawn and fish production, are being examined for their feasibility for the mass production of juvenile crabs.

Results:
Twenty-two preliminary trials have been completed so far. A study on the feasibility of larval rearing in ‘green water’ positively indicated that economical, commercial production of juvenile crabs may be achieved through better pond management.

Five trials on the mass production of juvenile crabs in semi-intensive systems failed at different instars up to the megalopa stage. Failure resulted from problems with pathogens, water quality management and rearing larvae at the wrong time of the season.

Various combinations of different types of live food at different densities and appropriate water quality management were used to improve larval survival. The sixteen trials completed so far resulted in a significantly higher survival rate, up to 68 %, for zoea 1 - zoea 2 instar but no larvae survived to megalopal instar. Nutritional deficiency, size of food and water quality are the factors being investigated to improve larval survival.
Nursery Rearing of Barramundi Fingerlings

Project Period: 1993-1994  
Project Officer: Glenn Schipp  
Project Location: Darwin Aquaculture Centre

Objective:  
To improve survival, growth and food conversion rates of barramundi through the nursery period.

Background:  
During 1993/94 a trial was undertaken to examine the potential for improving the growth, survival and feed conversion rates of juvenile barramundi between 25 and 100 mm in length. The first trial returned excellent results with a food conversion rate of 0.8 to 1, survival of 80% and fast growth. These results were achieved by regularly grading and paying particular attention to feeding rates. Two more nursery trials were undertaken during 1993.

Results:  
Trial number 2 took place between May 18 and July 21. The survival rate obtained of only 20% was very poor compared to the first trial. The reason for the poor survival was attributed to harvesting from the rearing pond at a very small size. Most of the losses occurred during the first two weeks in the nursery. The food conversion rate of 1.06:1 was acceptable.

The third trial produced a survival rate of 65%, which although not as high as the first trial, was still a reasonable return. The food conversion rate of 1.2:1 was higher than the other two trials and reflected the increased use of minced fish and prawn, as opposed to dry feeds, in this trial.

Golden Snapper Production

Project Period: 1993-1994  
Project Officer: Glenn Schipp  
Project Location: Darwin Aquaculture Centre

Objective:  
To examine the feasibility of the commercial production of golden snapper for marine aquaculture farms.

Background:  
Golden snapper, *Lutjanus johni*, has been identified by aquaculturists in several Southeast Asian countries as having excellent potential for culture in commercial mariculture farms.

The potential for golden snapper aquaculture has also been recognised in northern Australia and recent, preliminary rearing trials of golden snapper have confirmed this belief.

In 1993 the NT government provided funding for a three year investigation into the viability of commercial farming of golden snapper.

Results:  
During the 1993/94 golden snapper spawning season six spawning trials were undertaken. Larvae produced from these spawnings were then used in experiments designed to investigate optimal rearing conditions for the larvae. The experiments examined the effects of salinity, temperature, food type and disinfection procedures on the growth and survival of the larvae. The larvae were found to survive in a wide range of salinities and temperatures but a problem was encountered in identifying a suitable zooplankton animal for the larvae to feed on. Experiments planned for 1994/95 will continue to investigate this problem.

Gonads from wild golden snapper were collected throughout the spawning season and used to compare the reproductive condition of the wild fish and the broodstock kept in the hatchery. Results to date indicate that holding the fish in captivity does not inhibit reproduction.
AGRICULTURE DIVISION

INTRODUCTION
The start to the 1993/94 wet season in the north was similar to quite a few of those over the last 4-5 years with only very light and patchy storm activity during October/November. December produced reasonable falls, above average, January/February were well below average, March had average rainfall with small falls in April/May. The rainfall was sufficient to give good pasture growth over most of the season with virtually no waterlogging. High rainfalls recorded in Darwin were not experienced further east, however falls along the west coastal areas were marginally better.

The slow start to the season coupled with the early finish to the 1992/93 wet season made conditions at the end of the dry quite tight for feed in some areas, with stock suffering more weight loss than normal.

Increasing interest has been shown by producers in improving floodplain pastures and CPRS has embarked on an exciting program of floodplain ponding. The aim is to improve the dry season green pasture situation by reducing the floodplain run-off in the late wet/early dry season. The system basically retains water on the plain which would otherwise be lost as run-off through drainage lines. It has application throughout the coastal plains and may also be useful on floodout areas and many open river flats further inland. Most soils where there is some inundation and a clay content in the soil could be a potential site for this system of water harvesting.

It has huge potential for increasing cattle/buffalo production in the Top End, and also in the control of mimosa on the drier floodplain country, by increasing the vigour of grasses such as para, aliman and hymenachne.

INDUSTRY DEVELOPMENT - IMPROVED PASTURES

Evaluation of New Pasture Introductions at Opium Creek and Middle Creek Stations

Project Period: December 1988 - December 1995
Project Officer: A Cameron, B Lemcke, D Reilly and B Beumer
Project Location: Opium Creek Station/Middle Creek Station

Objective:
Monitor the adaptation of new pasture introductions to the coastal upland environment and to a non cropping yellow earth site in the Douglas Daly area.

Background:
A range of pasture introductions which have the potential to provide new pasture cultivars for the Top End of the Northern Territory are being grown in observations plots to determine their suitability for and adaptation to the coastal upland environment and further inland.

The coastal properties have good dry season pastures where animals graze the floodplains as they dry out. The upland pastures are poor and the use of improved pastures will allow producers to carry more stock during the wet season when the lowland pasture is unavailable due to flooding. Also, in the Douglas Daly area, many of the better cropping soils may be not available for grazing in the wet season because they are being utilised for crop or forage production.

Method:
Fifteen pasture introductions were sown at two sites on Opium Creek Station in December 1988. The sites sown were on upland yellow earth and a floodplain fringe site.

Twenty-one introductions were sown on another upland yellow earth site in January 1992 adjacent to a fertiliser trial site. Ten of these introductions are repeats of the previous sowing. Two introductions which did not establish in 1992 and one other introduction were sown during the 1992/93 wet season. One further introduction
was planted during 1993/94 wet season.

Nineteen pasture introductions were sown on the Middle Creek site in 1991/92 wet season and later sown in 1993/94.

Results:
Of the 22 introductions sown in 1992 or 1993 the highest yielding were *Stylosanthes sp.*, *aff scabra* CPI 104710, 110361 followed by *C. brasilianum* CPI 55696 and then *C. brasilianum* CPI 87987. The highest yielding grass was *Hyparrhenia* sp CPI 58456, while two *Digitaria milanjiana* lines CPI 40700 and 41192 are thickening up after a poor initial establishment.

This year 1993/94 at Opium Creek the *Stylosantes sp.*, *cf scabra* lines were particularly weak and looked most unimpressive. The most promising legume lines which re-established well were:
- *Centrosema brazilianum* CPI 87987
- *Cassia rotundifolia* CPI 86172
- *Amiga stylo/Verano Stylo*

Grasses showing up well this season were,
- *D. milanjiana* CPI 41192 and 40700
- *Hyparrhenia rufa* CPI 58456

Bisset (*Bothriochloa insulata*) sown this year did not appear to establish. The wet season rainfall total at this site was well below average.

At Middle Creek Station on the yellow earth site the following performed well,

**LEGUMES**
- *Amigo stylo*
- *Aeschynomene histrix*
- *Aeschynomene paniculata*

**GRASSES**
- *Digitaria milanjiana*
- *Digitaria swynnertonii*

The grasses have improved quite markedly compared with the first year.

### Evaluation of Pasture Introductions Under Grazing at Douglas Daly Research Farm

- **Project Period**: Continuing
- **Project Officers**: R Rann, A Cameron, C Tidswell, S Izod, B. Beumer and D. Reilly
- **Project Location**: DDRF

**Objective:**
To evaluate new and improved introductions and cultivars of both grasses and legumes for livestock production in the Douglas Daly district.

**Background:**
New pasture introductions are evaluated under grazing at DDRF to determine their persistence and productivity in the Douglas/Daly environment. Their performance is compared with a number of reference pastures which have remained productive for over 15 years.
Method:
An MRC funded trial to demonstrate the value for animal production of the shrub legumes leucaena cultivar Cunningham and Calliandra calothyrsus. They were sown on Blain soil in paddock 53 at DDRF during the 1992/93 wet season.

There are five paddocks in the trial, these being:
1. Grass only - Gayndah buffel and Nixon sabi;
2. Grass plus legume - Gayndah and Nixon and Wynn and Verano;
3. Grass plus 50% leucaena - Gayndah and Nixon plus half of the paddock sown with leucaena in rows 8 m apart;
4. Grass plus 25% leucaena - Gayndah and Nixon plus one quarter of the paddock sown with Leucaena in rows 8 m apart.
5. Grass plus 50% Calliandra - Gayndah and Nixon plus half of the paddock sown with Calliandra calothyrsus in rows 8 m apart.

The grasses and legumes were sown in early January 1993. There was a dry spell following sowing which was followed by a good period of monsoonal weather.

Seed of the shrub legumes inoculated with leucaena inoculant was to be sown in late January but the spell of monsoonal weather delayed the sowing until 12 February. The shrub legumes were sown with a single row leucaena planter borrowed from DPIF Katherine. This machine sprays a narrow band of herbicide in front of the sowing tyne to kill any weeds present. Roundup® at 2 L/ha was used, and the shrub legumes were sown at a rate of 22 and 14 seeds per metre of row for leucaena and calliandra respectively. Ideal conditions followed the sowing of the shrub legumes, that is two weeks of overcast, rainy weather.

Roundup® gave good plant kill in a band about 75 cm wide.

The rows of fodder types were fertilised with Crop King 150® at a rate of 10 g per metre of row on 25 February. The rows of shrub legumes were sprayed twice, with Fusilade® and with Basagran® each at 2 L/ha on 4 March to control emerging weeds.

Results:
In January 1994, in the shrub legume grazing trial, calliandra was again replanted after last year's failure. A similar result occurred this year with no calliandra whatsoever established by mid March 1994. There will be no further attempts at introducing calliandra in this trial.

Poor fence condition and lack of maintenance caused most paddocks of all the introduction area plots to be destocked during 1993-94 and repairs are under way to enable restocking.

The leucaena established well but has been incessantly grazed by cattle from a nearby paddock. A further season will be allowed for establishment before stocking in March 1995.

Weeds also need to be controlled to make this grazing comparison worthwhile.

Comparison of Grass Introductions Under Grazing at Coastal Plains Research Station

Project Period: December 1987 - June 1994
Project Officers: B Lemcke, A Cameron, E Cox, S Cross, B Beumer and D Reilly
Project Location: CPRS

Objectives:
To assess the performance of promising new grass introductions in continuously grazed pastures in the Top End coastal region.
To compare the performance of these new introductions with that of two currently recommended adapted pasture cultivars.

**Background:**
A number of grasses which have shown promise for release as pasture grass cultivars in introduction trials and cutting trials have been established in grazing paddocks at CPRS since 1988.

Five pasture grasses are being evaluated under grazing and being compared with pangola grass and tully for animal production.

It was expected that three of the five grasses would be released as new pasture cultivars.

**Method:**
Four hectare paddocks of 6 grasses, *Digitaria decumbens* (pangola), *D. milanjiana* (40700, 41192), *D. swynnertonii* (59749), *Hyparrhenia rufa* (59460) and *H. sp (rufa?)* (58456) and a 8 ha paddock of *Brachiaria humidicola* (tully) were established during the 1987/88 and 1988/89 wet seasons.

A mixture of commercial legume cultivars, Glenn, and Verano each at 1 kg/ha and Wynn at 2 kg/ha were sown in all of the paddocks except the Tully Paddock where only Glenn was sown. Legume establishment was good.

The established grass paddocks were to be grazed by cattle at a set stocking rate of one beast per hectare year round.

Fertilisers applied each wet season are superphosphate at 100 kg/ha and muriate of potash at 25 kg/ha.

Cattle live weights are recorded during each month of the year.

Samples are taken for pasture dry matter yield and composition four times annually during January, April, July and October.

**Results:**
1993/94 (fourth season of grazing).

Again the start to the 1993/94 wet season was slow until late November. Destocking was again necessary on Paddock 2, *D. milanjiana* (40700) and the tully (paddock 7) for two months over Dec/Jan 1994. All other paddocks had sufficient feed and growth to persist into the wet season.

Again the *H. rufa* paddocks 3 and 5 produced heavy excess dry matter in the mid to late wet season which the stock were unable to graze down. Paddock 3 now has substantially less dry matter (thinner sward) than the paddock 5 stand). Paddock 6 recovered sufficiently with the 16 month rest to be restocked at the end of January 1994.

The dry matter (DM) yields in Kg/ha late dry and late wet are tabled below.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>D.swym 59749</td>
<td>1850</td>
<td>630</td>
<td>5508</td>
<td>1834</td>
</tr>
<tr>
<td>D.mill 40700</td>
<td>1866</td>
<td>243</td>
<td>3970</td>
<td>1306</td>
</tr>
<tr>
<td>H.rufa 58460</td>
<td>1990</td>
<td>224</td>
<td>7562</td>
<td>1898</td>
</tr>
<tr>
<td>Pangola</td>
<td>1576</td>
<td>68</td>
<td>3044</td>
<td>584</td>
</tr>
<tr>
<td>H sp 58456</td>
<td>3097</td>
<td>46</td>
<td>15224</td>
<td>280</td>
</tr>
<tr>
<td>D.mill 41192</td>
<td>1794</td>
<td>276</td>
<td>3620</td>
<td>360</td>
</tr>
<tr>
<td>Tully</td>
<td>1681</td>
<td>490</td>
<td>2366</td>
<td>1790</td>
</tr>
</tbody>
</table>
Compared with 1993 the grass dry matter quantities in January 1994 were substantially higher - almost double in all except the *D. swynnertonii* which was similar. There was also substantially more forage dry matter in April 1994 than in April 1993, in all paddocks except the tully paddock which is showing a marked increase in legume content, whilst the grass percentage is falling.

This is despite fewer paddocks being destocked in late 1993 than was necessary in the previous year.

The group means live weight gains of the cattle are tabled below:

<table>
<thead>
<tr>
<th>Paddock/Species</th>
<th>Destock period</th>
<th>LWG (kgs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Out of Paddock</td>
<td>In Paddock</td>
</tr>
<tr>
<td>1. D. swynn 59749</td>
<td>1/12-25/1/94</td>
<td>121</td>
</tr>
<tr>
<td>2. D. mill 40700</td>
<td>1/7-25/1/94</td>
<td>50</td>
</tr>
<tr>
<td>3. H. sp 58456</td>
<td>1/12-25/1/94</td>
<td>145</td>
</tr>
<tr>
<td>4. Pangola</td>
<td>1/12-25/1/94</td>
<td>164</td>
</tr>
<tr>
<td>5. H. rufa 58460</td>
<td>1/12-25/1/94</td>
<td>119</td>
</tr>
<tr>
<td>6. D. mill 41192</td>
<td>1/12-25/1/94</td>
<td>66</td>
</tr>
<tr>
<td>7. Tully</td>
<td>1/12-25/1/94</td>
<td>40</td>
</tr>
</tbody>
</table>

Pangola has maintained its cattle weight gain superiority throughout the 4 years of the trial.

There was a marginal increase in the live weight gains on *D. swynnertonii* probably reflecting the better finish to the 1994 wet season compared with 1993, however the carry over of the poor 1993 wet season on subsequent dry matter availability in the 1993 dry season kept gains lower than in previous years.

The high gains of stock while out of the paddock are due to significant good feed being available for use at the critical early-mid wet season in saved paddocks elsewhere.

Animal variations are again high due to small numbers in each paddock, however, significant differences have emerged between paddocks.

The large differences emerging between paddock 3 and 5, both Hyparrhenia, are difficult to explain except that there is now a much higher legume content and half the grass dry matter in 3 compared with 5 which had much lower growth rates.

The *D. milanjiana* 40700 (paddock 2) is still out performing 41192 despite the long destocking period of that paddock for 16 months - which allowed good regeneration of the pasture. 40700 is on pre release in Queensland so should be available commercially within 3 years.

*D. swynnertonii* has shown sufficient promise for it to be recommended for release in the NT due to its superior performance over tully which is currently widely used.

### Comparison of legume introductions under grazing at Coastal Plains Research Station.

- **Project Period:** December 1991 - December 1997
- **Project Officers:** B Lemcke, A Cameron, E Cox, S Cross, B Beumer and D Reilly
- **Project Location:** CPRS

**Objectives:**
Assess the performance of promising new legume introductions in continuously grazed pastures in the Top End coastal region. Compare the performance of these new introductions with currently recommended adapted pasture cultivars.
Background:
A number of pasture legumes have performed well in observation and cutting trials.

These legumes need to be evaluated under grazing to determine their value for animal production before they can be released as new pasture cultivars.

Ten pasture legumes are to be evaluated under grazing and compared with the commercial cultivars Glenn, Wynn, Bundey Cavalcade, Maldonado and Verano. It is expected that up to 5 of the legumes will be released as new pasture cultivars.

Method:
Four hectare paddocks of 13 legumes were sown at CPRS with Kazungula setaria as a companion grass in December 1991. The legumes sown are listed below:

*Aeschynomene americana* cv Glenn
*A. histrix* 93636
*A. paniculata* 93635
*Cassia rotundifolia* cv Wynn, 85836, 86172, 8617
*Centrosema brasilianum*
   Early maturity mix (40067/92409)
   Mid maturity mix (55696/55698)
   Late maturity mix (58587/87987/94315)
*C. pascuorum* mix cv Bundey/Cavalcade
*C. pubescens* 58575
*Macropitilium longepedunculatum* cv Maldonado

In 1992 the establishment of the Kazungula was good. The establishment of the legumes was fair to good, except for *C. pubescens* which was poor and Maldonado which was excellent. Establishment was good considering the low and patchy rainfall experienced during the wet season.

Re-establishment in the wet season of Glenn was poor. There was little legume present in January 1993. The paddock was slashed and oversown with more Glenn seed.

These paddocks except Glenn have been grazed from February 1992 at a stocking rate of 1 beast/1.3 ha. (3 head per 4 ha paddock) by Brahman cross and Droughtmaster yearling steers ex VRSS. These stock were replaced by a new batch of yearlings on 30 June 1994.

Results:
The Glenn paddock still had little legume present during the 1993/94 wet season and was not stocked.

Dry matter yields for the 13 paddocks are presented below for early and late wet season 1994

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><em>C. pubescens</em> Res/Lee</td>
<td>8</td>
<td>RESOWN</td>
<td>558</td>
<td>RESOWN</td>
<td>2434</td>
</tr>
<tr>
<td><em>C. pascuorum</em> Resown</td>
<td>9</td>
<td>RESOWN</td>
<td>1422</td>
<td>RESOWN</td>
<td>1600</td>
</tr>
<tr>
<td><em>C. brasilianum</em> (Early)</td>
<td>7</td>
<td>15</td>
<td>58</td>
<td>2044</td>
<td>2822</td>
</tr>
<tr>
<td><em>C. brasilianum</em> (Mid)</td>
<td>5</td>
<td>34</td>
<td>167</td>
<td>1894</td>
<td>3860</td>
</tr>
<tr>
<td><em>C. brasilianum</em> (Late)</td>
<td>6</td>
<td>46</td>
<td>128</td>
<td>2392</td>
<td>3801</td>
</tr>
<tr>
<td>Maldonado</td>
<td>10</td>
<td>72</td>
<td>322</td>
<td>2033</td>
<td>3564</td>
</tr>
<tr>
<td>Glenn</td>
<td>13</td>
<td>21</td>
<td>140</td>
<td>1608</td>
<td>3348</td>
</tr>
<tr>
<td><em>A. histrix</em></td>
<td>12</td>
<td>117</td>
<td>235</td>
<td>2415</td>
<td>3277</td>
</tr>
<tr>
<td><em>A. paniculata</em></td>
<td>11</td>
<td>1483</td>
<td>4762</td>
<td>1524</td>
<td>3868</td>
</tr>
<tr>
<td>Wynn</td>
<td>2</td>
<td>644</td>
<td>1054</td>
<td>2797</td>
<td>3320</td>
</tr>
<tr>
<td><em>C. rot</em> 85836</td>
<td>3</td>
<td>273</td>
<td>4098</td>
<td>3012</td>
<td>2862</td>
</tr>
<tr>
<td><em>C. rot</em> 86172</td>
<td>4</td>
<td>240</td>
<td>427</td>
<td>3922</td>
<td>3169</td>
</tr>
<tr>
<td><em>C. rot</em> 86178</td>
<td>1</td>
<td>755</td>
<td>2279</td>
<td>2594</td>
<td>3850</td>
</tr>
</tbody>
</table>
Grass yields are generally lower than at the same period last year due to continuous stocking compared to 1993. However most legume yields have increased or stayed much the same. In 1993 it would have been a poor year for legume seed yields however 1994 was a much more favourable one. This should make for a better legume content in the 1994/95 wet season.

Live Weight Gains
Mean starting live weight on 10/2/93 was 202.5 kgs. Results of live weight changes per head to 30/6/94 are tabulated below:

<table>
<thead>
<tr>
<th>Paddock</th>
<th>Mean LWG adjusted for gains out of paddock</th>
<th>Mean LWG (kg) 10/2/93 - 30/6/94</th>
<th>Mean fat P8 depth (mm) 30/6/94</th>
</tr>
</thead>
<tbody>
<tr>
<td>C. rot 86178</td>
<td>208</td>
<td>208</td>
<td>10.3</td>
</tr>
<tr>
<td>C. rot Wynn</td>
<td>235</td>
<td>235</td>
<td>9.6</td>
</tr>
<tr>
<td>C. rot 85836</td>
<td>229</td>
<td>229</td>
<td>10.7</td>
</tr>
<tr>
<td>C. rot 86172</td>
<td>242</td>
<td>242</td>
<td>8.11</td>
</tr>
<tr>
<td>Centroserna brasiliannum (M)</td>
<td>247</td>
<td>248</td>
<td>11.0</td>
</tr>
<tr>
<td>Centroserna brasiliannum (L)</td>
<td>258</td>
<td>258</td>
<td>14.0</td>
</tr>
<tr>
<td>Centroserna brasiliannum (E)</td>
<td>138</td>
<td>193</td>
<td>7.3</td>
</tr>
<tr>
<td>Centroserna pubescens</td>
<td>51</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>C. pascuorum</td>
<td>68</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Maldonado</td>
<td>226</td>
<td>243</td>
<td>13.3</td>
</tr>
<tr>
<td>A. histrix</td>
<td>270</td>
<td>270</td>
<td>12.7</td>
</tr>
<tr>
<td>A. paniculata</td>
<td>278</td>
<td>278</td>
<td>9.0</td>
</tr>
<tr>
<td>Glenn</td>
<td>not stocked</td>
<td>not stocked</td>
<td>not stocked</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>240.3</td>
<td>10.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Paddocks</th>
<th>12 months LWG to 30/6/94 adjusted for gains outside paddock</th>
</tr>
</thead>
<tbody>
<tr>
<td>C. rot 86178</td>
<td>149</td>
</tr>
<tr>
<td>C. rot Wynn</td>
<td>162</td>
</tr>
<tr>
<td>C. rot 85836</td>
<td>169</td>
</tr>
<tr>
<td>C. rot 86172</td>
<td>177</td>
</tr>
<tr>
<td>Centroserna brasiliannum (M)</td>
<td>165</td>
</tr>
<tr>
<td>Centroserna brasiliannum (L)</td>
<td>175</td>
</tr>
<tr>
<td>Centroserna brasiliannum (E)</td>
<td>69 *</td>
</tr>
<tr>
<td>Centroserna pubescens</td>
<td>51 *</td>
</tr>
<tr>
<td>C. pascuorum</td>
<td>68 *</td>
</tr>
<tr>
<td>Maldonado</td>
<td>150</td>
</tr>
<tr>
<td>A. histrix</td>
<td>180</td>
</tr>
<tr>
<td>A. paniculata</td>
<td>193</td>
</tr>
<tr>
<td>Glenn</td>
<td>not stocked</td>
</tr>
</tbody>
</table>

* These paddocks destocked for sometime during the year.

There were no statistically significant differences because of the low number of stock per paddock for the 12 month period July 1993 - June 1994. There is some variation in soil type.

Of significance is the pasture dynamics where paddocks, 7,8,9 and 10 are struggling to maintain the legume, (8 & 9 were actually resown in January 1994 - paddock 9 to Cavalcade and paddock 8 to Lee joint vetch.

Also the *A.histrix* is at a low level in the pasture and may not persist as well as others in the longer term. It
appears more palatable than *A. paniculata*.

*A. paniculata* and the *Cassias* all appear to be increasing their dry matter yields in the pasture over the second year of growth.

The performance of the *A. histrix* animals may have been influenced by one outstanding steer which still had one testis. This animal performed way beyond the average of the trial animals. A second year's grazing data will be critical in confirming this year's trends.

---

**Pasture Introductions at Berrimah Agricultural Research Centre**

<table>
<thead>
<tr>
<th>Project Period</th>
<th>Continuing - June 1995 (?)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Officers</td>
<td>A Cameron, B Beumer and D Reilly</td>
</tr>
<tr>
<td>Project Location</td>
<td>BARC</td>
</tr>
</tbody>
</table>

**Objectives:**
To grow selected lines of pasture species for seed increase.

To select new introductions to test for suitability to the Top End environment.

**Background:**
New introductions of pasture from adapted genera and species are grown under controlled conditions to determine their suitability in the Top End of the NT.

Lines which have grown well in trials are grown for seed increase to provide seed to sow areas for grazing evaluation which is required before they can be released as new pasture cultivars.

**Method:**
The focus of the 1993/94 activities was the seed increase of promising pasture species at Berrimah Farm. In July 1994 there were 1 grass and 10 legumes in this category.

There were also 5 commercial grass cultivars with which we have had little experience, sown for observation/seed increase. Also present were 7 grass, 3 legume and 12 shrub legume introductions in small observation plots. The majority of these 27 introductions were carried over from previous years.

**Results:**
A late finish to the wet ensured a reasonable seed yield from all the seed increase plots, with one exception, the *D. swynnertonii* area. The main reasons for this was firstly geese and later on, an invasion of legumes mainly *Cassia pilosa* and Wynn.

Of the 12 legume shrubs, *Acacia* CPI 91331 and *Calliandra* CPI 108458 are still the most productive and persistent to date.

---

**Evaluation of the Residual Value for Pasture Legumes of a New Phosphorus and Sulfur Fertiliser SR 13**

<table>
<thead>
<tr>
<th>Project Period</th>
<th>December 1991 - August 1998</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Officers</td>
<td>A Cameron, B Lemcke, D Reilly</td>
</tr>
<tr>
<td>Project Location</td>
<td>Opium Creek Station/Texfern Station</td>
</tr>
</tbody>
</table>

**Objective:**
To evaluate a newly released fertiliser SR 13 which has 50% of its phosphorus and sulfur as slow release components which are resistant to leaching losses.
Background:
SR 13 is a new phosphorus and sulphur fertiliser developed specifically for top dressing pastures in the high rainfall districts of Victoria and South Australia where soils are acid and sandy. On these soils, fertilisers are quickly leached from the top soil.

SR 13 contains 50% of its phosphorus as slow release reactive rock phosphate and 50% of its sulphur as elemental sulphur. These slow release components resist leaching and provide a constant supply of nutrients during the growing season.

The analysis of this product is 9.3% P and 13.3% S, which is similar to the analysis of superphosphate at 9% P and 10% S. This fertiliser has the potential to reduce the costs of fertiliser applications to pastures by reducing the amount of fertiliser applied or the frequency of application.

Method:
The trial consists of four repetitions of a randomised block design at two sites, one being on a Yellow earth soil at Texfern Station (Middle Creek, Douglas Daly), the other site is a Yellow earth soil on the coastal upland area at Opium Creek Station.

The test plant is Verano (*Stylosanthes hamata*). Plots are 4 m x 2 m with 2 m laneways between plots.

The fertiliser treatments are superphosphate and SR 13 each applied as listed below.

1. 100 kg/ha  applied annually
2. 100 kg/ha  applied biennially
3. 200 kg/ha  applied annually
4. 200 kg/ha  applied biennially
5. 200 kg/ha  applied triennially
6. 200 kg/ha  applied year 1 only
7. 400 kg/ha  applied biennially
8. 400 kg/ha  applied triennially
9. 400 kg/ha  applied year 1 only
10. Control

Gypsum (18% S) is applied with the superphosphate treatments to equalise the rate of sulfur application to that of the SR 13 fertiliser.

There are a total of 76 plots at each site.

Basal fertiliser of zinc chloride (46% Zn) will be applied at 10 kg/ha in the first, third and fifth years of the trial.

Verano was sown at a rate of 10 kg pods/ha on 16/12/91 at Texfern and 8/1/92 at Opium Creek and 24 March 1994 (Texfern).

Results:
The yields from the Texfern site are presented in the Table 1 below:

<table>
<thead>
<tr>
<th>Fertiliser Applied Kg/ha</th>
<th>Superphosphate</th>
<th>SR 13</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1201</td>
<td>1201</td>
</tr>
<tr>
<td>100</td>
<td>7383</td>
<td>6418</td>
</tr>
<tr>
<td>200</td>
<td>6067</td>
<td>6139</td>
</tr>
<tr>
<td>400</td>
<td>6420</td>
<td>7066</td>
</tr>
<tr>
<td>Fertiliser Mean</td>
<td>5268</td>
<td>5206</td>
</tr>
</tbody>
</table>
Verano yields Opium Creek Station 1994.

<table>
<thead>
<tr>
<th>Fertiliser Applied kg/ha</th>
<th>Superphosphate</th>
<th>SR 13</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3095</td>
<td>3095</td>
</tr>
<tr>
<td>100</td>
<td>6961</td>
<td>6702</td>
</tr>
<tr>
<td>200</td>
<td>7107</td>
<td>6355</td>
</tr>
<tr>
<td>400</td>
<td>7861</td>
<td>7464</td>
</tr>
<tr>
<td>Fertiliser Mean</td>
<td>6256</td>
<td>5904</td>
</tr>
</tbody>
</table>

INDUSTRY DEVELOPMENT - LIVESTOCK PRODUCTION

BUFFALO BREEDING PROGRAMME AT COASTAL PLAINS RESEARCH STATION PROJECT 7.6.1

Project Period: 1986 - 1994
Project Officers: B Lemcke, E Cox, S Cross, CPRS Staff
Project Location: CPRS

Objective:
Develop an open nucleus breeding program in the buffalo industry using the herd at CPRS as the nucleus herd.

To continue to select for increased productivity of the Australian swamp buffalo.

Background:
The CPRS buffalo breeding herd originated from feral stock in 1970 and was run as a comparison unit with Brahman cross cattle. Heifers were drawn from many different locations. Further introductions from feral herds occurred during 1981 - 1983 to build herd size, along with gradual improvements in the quality and quantity of improved pastures on the station.

In 1986, as a result of the measured superiority of buffalo over cattle, an increased research effort was put into buffalo to determine whether further advances could be achieved through a selection programme. The herd target is 300 breeders, the objective being to provide selected bulls and heifers to industry over the long term.

The herd was recorded three times during 1993-1994. Ten single-sire mating groups were formed during January 1994 and the bulls introduced to the groups in mid February. This year, no fertility or semen tests were performed on the mating bulls in case this procedure was causing some of the short term problems encountered in previous years. Bulls were changed between groups mid-period (given a two week break in between) and withdrawn from the groups in mid June.

Pregnancy diagnosis was carried out at both the September 1993 and December 1993 recordings.

Results:
From the 1993 mating period eight single sire and one multisire mating groups gave the following calving results in 1994.
### Recorded Deaths: (July 93 – June 94)

<table>
<thead>
<tr>
<th>Deaths</th>
<th>Causes</th>
<th>Culls</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulls</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Breeder</td>
<td>Broken Leg</td>
<td>31</td>
<td>35</td>
</tr>
<tr>
<td>Breeder</td>
<td>Snake Bite</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weaners</td>
<td>Unthriftiness</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Calves</td>
<td>Poor Condition</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Calves</td>
<td>Early Post Natal</td>
<td></td>
<td>13</td>
</tr>
</tbody>
</table>

### Sales:

- Cull Breeder Bull: 1 To meatworks (poor reproduction)
- Breeder Bulls: 15 14 sold to Swim Creek Station 1 sold to Humpty Doo
- TENDER.BUFF®: 85 Some extras from Berrimah Farm and carry over from 1992/93
- Cows Cull: 31 (Culled for poor reproduction or temperament problems)

1993/94 produced significantly better calving results than in previous years. This is reflected in the lowering of the percentage of non-pregnant dry cows and an increase in the pregnant dry cows. There was also a slight increase in the percentage of pregnant and wet cows and a larger decrease in the percentage of non-pregnant wet cows.

If this result is repeated again for the 1994 mating it will be a breakthrough in the fertility problems due to single sire matings. It does complicate sire identification of some calves conceived around the changeover period. DNA testing may resolve this pedigree problem. Heifer pregnancies were a considerable improvement despite low starting weights of the heifers, over last year. Significant improvements could be expected if a larger proportion of heifers were above the 350 kg mark at the start of mating. This could be achieved by better nutrition of this group throughout the year.
A 57% increase in the number of calves from the previous year with only a 25 head (9%) increase in breeder numbers is gratifying.

The variation between mating groups in calves produced has been significantly reduced. Only 1 group in 1994 had less than 50% (46%) calving compared to 3 groups in 1993 which were all below 25%.

There was a slight increase in breeder death rates but it is still only marginally above 1% per annum. Calf losses remained static on 7%.

The top TEN 2 year old bulls were selected and the balance of the two year old males were used in the TENDER.BUFF® program.

Fifteen selected bulls were made available for sale to industry, 14 of which went to Swim Creek Station (Point Stuart).

♦♦♦ TENDER.BUFF® Market Supply and Development

Project Period : 1993 - 1996
Project Officers: B Lemcke, P Graham, E Cox and S Cross
Project Location: Top End properties

Objective:
To supply and foster a quality assured TENDER.BUFF product for local and interstate markets.

Background:
Because of the huge impact on the buffalo population from BTEC, traditional buffalo meat markets are now more difficult to supply because of the quantities required. The philosophy behind the TENDER.BUFF® programme is to maximise the returns per head from those buffalo males available from the limited remaining breeding herd.

A traditional local market for feral sourced buffalo fillets with restaurants had built up over the years but the volume is no longer available. This could be substituted by a wider range of cuts from TENDER.BUFF® carcases.

The DPIF in conjunction with the Buffalo Industry Council runs a quality assurance program to enable wholesalers and butchers to purchase with confidence.

Litchfield Abattoir is capable of processing 30 head per day (4 days per week) so local and interstate markets can now be catered for regularly to a limited extent. The health benefits of meat with lower fat and cholesterol than beef should be heavily used in marketing this product. There appears to be good demand interstate for the restaurant trade and demand during the tourist season in Darwin is brisk.

The current problem in supplying interstate is the lack of supply of sufficient suitable stock numbers.

Method:
The DPIF is supplying 2 year old male buffalo bulls for this market to supplement those supplied from industry sources. DPIF is also supplying the manpower for the quality assurance processing. A grid pricing system and a carcase strip brand completes the package.

TENDER.BUFF specifications are:
130-200 kg hot standard carcass weight (HSCW) at 3-6 mm rump fat thickness (revised 30/6/94 to 150-220 kg at 2-6 mm fat thickness).
2-12 mm fat on rump P8 site.
No permanent teeth erupted.
Electrically stimulated carcase.
Ultimate muscle pH (24 hrs) of less than 5.8.

Results:

<table>
<thead>
<tr>
<th>JANUARY - DECEMBER 1993</th>
<th>JANUARY - JUNE 1994</th>
</tr>
</thead>
</table>
| Total Number            | 215 head            | Total Slaughtered | 123 head *
| Mean Live weight (where known) | 373 kgs            | Mean Live weight | 393 kgs |
| Mean H.S.C.W.          | 177 kgs             | Mean H.S.C.W.    | 172 kgs |
| Mean Eye Muscle Area   | 52 cm²              | Mean Eye Muscle area | 52 cm² |
| Mean pH                | 5.57                | Mean pH          | 5.63   |
| Mean Carcase Length    | 98 cms              | Mean Carcase Length | 98 cms |
| Mean Gross $           | 513.99              | Mean Gross $     | 508.76 |
| Mean Grid $/kg         | 2.19                | Mean Grid $/kg   | 2.93   |
| Mean Dressing %        |                     | Mean p8 fat      | 3.28 mm |

* This compares with 73 killed during the same period last year.

The producer pays the kill fee of $50.00 per head and receives $3.10 per kg HSCW provided all specifications are met. The wholesaler also pays the BIC a 10cents/kg carcase levy to help with supply and marketing promotion. Discounts apply for every specification not met and are compounded if multiple specifications are not complied with.

As reported last year the good primal cuts are readily sold. While burgers and sausages are popular, there is usually still some difficulty in maintaining demand for forequarter cuts such as blade and chuck. A good volume pie maker would be the ideal repository for this product but as yet this marketing outlet has not been achieved. It should be a popular product with the tourist trade in all the roadhouses throughout the Northern Territory.

During 1993-94 there was a period of 6 weeks over December - January where there were no supplies available but currently there appear to be sufficient stocks for this disruption not to occur in 1994/95.

PLANT PRODUCTION

- - - The Value of Mungbean in Rotation with Sorghum

Project officers: S Yeates and M Kahl.
Project Location: KRS

Objectives:
To quantify the effect of mungbean on the yield and nitrogen economy of a subsequent grain sorghum crop.
Background:
Most farmers assume there will be benefits in growing sorghum in rotation with mungbean. However, the effects of mungbean on the yield and nitrogen economy of a following sorghum crop have never been quantified. This means it is not possible to effectively cost this rotation to the farm as a whole.

Method:
Three rotations are being compared: continuous sorghum, sorghum/mungbean (only grain harvested) and sorghum/mungbean (grain and stover removed). The nitrogen benefit to the following crop was determined by superimposing rates of nitrogen fertiliser.

Results:
Provided that the mungbean stover was retained, continuous sorghum required approximately 40 kg/ha of fertiliser nitrogen to give the equivalent yield of unfertilised sorghum that followed mungbean. Where mungbean stover was removed, the response to fertiliser nitrogen was reduced and yields were equal to the continuous sorghum rotation.

It is not clear if the effect of removing stover was entirely due to lower soil nitrogen or whether the reduced response to nitrogen fertiliser was due to lower soil moisture. This is because the removal of stover also reduced the infiltration of rainfall into the soil.

---

The Management of Soil Vegetative Cover Prior to Sowing on Weed Competition in No-till Sorghum

Project Period: 1992-1995
Project Officers: S Yeates, M Kahl and C Martin
Project Location: KRS, DDRF

Objectives:
To evaluate the effects of the herbicide management used to kill vegetation cover prior to sowing and the thickness of this cover on weed competition in no-till sorghum.

Background:
In previous experiments, where knockdown herbicide was applied at sowing, the weight of dead vegetative cover was higher and the weight of in-crop weeds was lower than where knockdown herbicide applications were made 10 to 14 days prior to sowing. It is not clear from these experiments whether the thicker mulch or the later herbicide application caused the suppression in weed growth. Research was required to evaluate the separate effects of knockdown herbicide management and the amount of mulch present at sowing on weed competition.

Method:
Two experiments were conducted at each site:

Experiment 1 - The effect of the thickness of vegetative cover.
Treatments
1. Minimum cover to protect soil from erosion, < 1 t/ha, 30% ground cover
2. Low thickness - approx 0.7 to 1 t/ha, 100% ground cover
3. Medium thickness - approx 2 to 3 t/ha, 100% ground cover
4. High thickness - > 5 t/ha, 100% ground cover

Experiment 2 - The effect of time of herbicide application.
Treatments
1. Glyphosate applied 14 days prior to intended sowing.
2. Glyphosate applied at sowing.
3. Glyphosate applied 7 days prior to intended sowing.
4. Glyphosate applied 14 days prior to intended sowing and at sowing
Results:
Data analysis is not completed. Sorghum yields were significantly higher and weed weights significantly lower where glyphosate was applied at sowing. High and medium mulch thickness also produced significantly higher sorghum yields and significantly lower weed weights.

Demonstration of Conservation Tillage in Mixed Farming

<table>
<thead>
<tr>
<th>Project Period</th>
<th>1992 - 1996</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project officers</td>
<td>F O'Gara, S Yeates and M Bennet</td>
</tr>
<tr>
<td>Project Location</td>
<td>Upper Daly Basin and Sturt Plateau</td>
</tr>
</tbody>
</table>

Objectives:
Encourage the integration of conservation tillage technology in crop/pasture rotations and in the complete range of crops grown in the region.

Method:
The project is funded from the National Landcare Program. Two x 20 ha demonstration sites were established on-farm. A rotation of sorghum with cavalcade is being demonstrated at Carbeen Park. At Cutla Cutla farm, sorghum, in rotation with three species of legume, is being demonstrated. At this site 10 ha of cavalcade, and 5 ha each of Maldinado and Wynn cassia have been established. At each on-farm site sorghum will be established using no-till every third year, the pasture will be sustainably grazed in the other two years. Demonstrations of no-till mungbean and sesame will be made on-farm each year. This season these demonstrations were located at Garibaldi farm.

Results:
The Garibaldi demonstration was the first commercial crop of sesame to be successfully grown using no-till in the Douglas Daly. The sesame and mungbean areas were viewed by local farmers and Departmental staff on separate tours. Five hectares of sorghum was successfully grown after cavalcade at Cutla cutta farm, the stubble and legume intercrop are being grazed during the dry season. The aim of the grazing is to demonstrate the benefit of retaining soil cover at the commencement of the wet.

Development of Improved Sesame Cultivars

<table>
<thead>
<tr>
<th>Project Period</th>
<th>1992 - 1997</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Officer</td>
<td>M Bennett</td>
</tr>
<tr>
<td>Project Location</td>
<td>DDRF and KRS</td>
</tr>
</tbody>
</table>

Objective:
Identify and develop a sesame cultivar with capsule characteristics that minimise seed loss during crop maturation, while retaining the high seed yield and seed quality of the recently selected Northern Territory cultivar.

Background:
The new sesame cultivar selected for the NT (Y1:44), does not have capsule characteristics that minimise pre-harvest shattering losses. Breeding lines with these characteristics are available. A project to incorporate these characteristics into Y1:44 was submitted to RIRDC for funding. This application was successful.
Method:
A 4 year sesame breeding program was designed by CSIRO. Each year 2 generations of crossing are implemented.

Progress Report:
Year 1 - Dry season. Sesame parents were successfully crossed.
Year 1 - Wet season. Hybrid plants were grown to produce selfed seed.

The first back cross to be undertaken during the 1994/95 wet season.

Progress Reports were submitted to RIRDC in July and December.

★★★ Desiccation of Sesame

Project Period : 1993 - 1995
Project Leader : M Bennett
Project Location: KRS

Objective:
Determine the optimum time and rate of Reglone® application for the desiccation of sesame.

Background:
The use of Reglone® as a desiccant has been effective in reducing pre-harvest losses in sesame in Queensland. For sesame cultivars harvested under Northern Territory conditions, there is no information on rates and times of Reglone application.

This investigation will identify the correct desiccation practices.

Material and Method:
Experimental design was a randomised complete block with a factorial combination of 4 rates of Reglone® application and 4 times of application. After application of the first treatment all plots were sampled every 3 days to monitor the drying down process of the crop and seed quality.

Progress Report:
Preliminary results indicate that desiccated sesame can be harvested as early as 6-7 days after spraying to minimise seed losses. An application rate of 1.5L/ha Reglone® will successfully desiccate a sesame crop.

Publications:
Seasonal Research Report 1993 - 1994

★★★ Effect of phosphorus and potassium on sesame seed yield

Project Period : 1993 - 1995
Project Officer : M Bennett
Project Location: DDRF

Objective:
Evaluate the effect of phosphorus and potassium on sesame seed yield.

Background:
There is a paucity of information on fertiliser requirements for sesame other than nitrogen. As sesame is generally grown on sandy clay loam, phosphorus and potassium are two other major nutrients that require investigation.
Method:
Experimental design was a randomised complete block with a factorial combination of four rates of phosphorus application and 3 rates of potassium application. At harvest grain weights were measured and samples collected for nutrient analysis.

Progress Report:
Preliminary results indicate that an application of 50 kg K/ha or 60 kg P/ha produced a seed yield increase.

HORTICULTURE DIVISION

Horticulture Division has six Branches, Ornamental Crops, Annual Crops, Perennial Crops, Irrigation, Post Harvest Research and Winged Vertebrate Pest Research.

ORNAMENTAL CROPS

The Effect of Four Different N:K Fertiliser Ratios Applied on Yield and Flower Quality of Heliconia psittacorum cv ‘Susi’

Project Period: 1992 - 93
Project Officers: J Powell, D Nielsen and P Albano
Project Location: Berrimah Agricultural Research Centre (BARC)

Objective:
To determine the optimum N:K ratio in applied fertilisers for cut-flower production of Heliconia psittacorum in the Darwin area.

Background:
Over the last ten years heliconias have developed as a commercial cut-flower crop in many tropical areas of the world. The major species used for cut-flower production is Heliconia psittacorum. As it is a new crop, relatively little research has been carried out on many aspects of its culture. Early published work on plant nutrition focussed solely on nitrogen with up to 650 g N/m²/year being applied, with flower production still increasing.

Early in the development of the industry in Darwin, examples of K deficiencies were noted at various locations. In the absence of any published information, practices used on the related plant banana (Musa sp.) were adopted for heliconia cultivation with N:K ratios of 1:1 - 1:1.5 being applied. As most of the soils in the horticulture area around Darwin hold very small amounts of nutrients (and little water) regular applications of most fertilisers are required. It was decided to try out four different N:K ratios (1:1, 1:1.5, 1:2 and 1:3) as a preliminary step towards determining the optimum fertiliser practice for heliconia flower production.

Method:
The design of the trial was a completely randomised block with four treatments and four replicates of each treatment. Each replicate consisted of one square metre area of soil surrounded by strips of fibreglass roofing material buried 20 cm into the ground to prevent the spread of the plants.

In preparation for planting, 200 g/m² dolomite and, because the soil had been cultivated for many years, only one application of phosphorus in the form of 50 g/m² single superphosphate was applied. A 3 cm layer of a black decomposed peat was also incorporated into the soil to improve the moisture and nutrient holding capacity. In November 1991 four rhizomes of Heliconia psittacorum cv ‘Susi’ were planted into each replicate.

Every two weeks each replicate was top-dressed with urea, potassium nitrate and, if necessary, potassium chloride, thus giving a constant application of 300 g N/m²/year over all the treatments. Regular spray applications of manganese sulphate were also applied. Pest and disease control measures were carried out as required.

From the onset of flowering till March 1993 the flowers were picked twice per week and the following measurements were taken: Stem length, stem caliper, flower size and quality. Prior to measuring stem length, the flowers were stripped of all but the last leaf and the stem was cut in the middle of the transition area between white soft tissue and green, harder tissue. Flower size was calculated by adding the length of the first and second bracts. Quality was a subjective 1 to 5 rating and a marketable stem was defined as one with stem length ≥65 cm, flower size ≥20 and quality ≥3 (‘Susi’ is a cultivar which produces relatively small flowers on relatively short stems for Heliconia psittacorum).
Results:
There were significant differences in stem length, flower size, quality and marketable yield between treatments. In all cases the best treatment was the first treatment which received an N:K ratio of 1:1, although this was never significantly different from treatment 2 (1:1.5). For marketable yield, the treatments were ranked in order of increasing K application. It has been observed that as *Heliconia psittacorum* beds get older, they get more crowded, stem length increases but flower size can be reduced. It was thought that at this time, the N:K ratio may have a more pronounced effect on these characteristics. The effect on marketable yield and flower size is still apparent but there is no significant effect on quality. Again, there is no significant difference between the first two treatments. It is suggested that growers use an N:K ratio of 1:1 for their fertiliser applications. Another trial with N:K ratios ranging from 1:0.8 to 1:1.5 would be beneficial in more clearly defining optimum regimes for N and K application.

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**The Influence of Various Shading Levels on Flowering of Dendrobium ‘Sonia’**

**Project Period:** 1991 - 1994  
**Project Officers:** J Powell, D Nielsen and P Albano  
**Project Location:** Berrimah Agricultural Research Centre

**Objective:**  
To determine the optimum commercially available black shadecloth for Dendrobium orchid production in the Darwin area.

**Background:**  
There has been considerable debate around Darwin as to which is the best shade-cloth for Dendrobium orchid production. Current industry practice is to use 70% black shade-cloth. Fifty percent black shade-cloth is used in both Thailand and Hawaii where intensity of sunlight and number of sunlight hours per year are both less. One Darwin grower used 60% white shadecloth with very poor results. The light inside the shadehouse was very intense and the plants were burned - in fact the shadecloth only provided 45% shade.

**Method:**  
As previously reported (Technical Annual Report 1992/93) 60 Dendrobium ‘Sonia’ plants were obtained from a local flower grower. The plants were approximately 18 months old. They were potted into clay pots with coarse pine bark growing medium. Twenty of the plants were hung under each of the three different shade treatments: 80%, 70% and 50% black shade-cloth.

The plants were irrigated once a day during cool weather and twice daily during hot periods. Liquid fertiliser was applied once per week. Pest and disease control was carried out as required. At weekly intervals, stem length, number of flowers per stem and number of bud-drop was recorded for each stem picked. A marketable stem was defined as one with a stem length <40 cm and bud-drop ≤1.

**Results:**  
These results confirm the results for the first flowering season (Technical Annual Report 1992-93). The optimum shading level would appear to be 60%. As this is currently unavailable unless a special production run can be afforded, the best option would probably be to use 70% for open areas and 50% if the shadehouse is to be built in a protected situation (eg. surrounded by trees).

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**Ginger Breeding**

**Project Period:** 1991 - 1995  
**Project Officers:** J Powell, D Nielsen and P Albano  
**Project Location:** Berrimah Agricultural Research Centre (BARC)

**Objective:**  
To breed and release to industry new cultivars of *Alpinia purpurata* which will improve the range currently available to growers in Australia.
Background:
Alpinia purpurata has been cultivated as a cut-flower in Hawaii since before the development of heliconia about ten years ago. As late as 1991 the value of ginger production still exceeded the value of heliconias. Alpinia purpurata also shows considerable potential for cultivation as a cut-flower in Australia. Currently the cultivars available to industry in Australia include ‘Red Ginger’ which has a red elongated inflorescence, ‘Eileen McDonald’ which has a pink elongated inflorescence, the tips of the bracts of which are faded. Alpinia purpurata ‘Jungle King’ has inflorescences which are purplish red and a rounded top and ‘Jungle Queen’ inflorescences are white with a pale pink tinge around the base and a more conical shaped top. ‘Red Ginger’ and ‘Eileen McDonald’ are both higher yielding than ‘Jungle King’ and ‘Jungle Queen’ which produce tall thick stems with large flowers when mature. It was considered that a cross between a red cultivar and an almost white cultivar would increase the range of colours available for cut-flower production and ornamental plants.

Method:
Early in 1991 a cross was successfully made with ‘Jungle King’ as the male parent and ‘Jungle Queen’ as the female parent. The seed was germinated and grown in 300 mm containers. After the plants were well established in 300 mm containers they were planted out under 50% shade. For a period of approximately 12 months, from the onset of flowering the flowers were assessed for yield vase-life and flower colour and attractiveness (subjective).

Results:
The forty seedlings showed intermediate characteristics in inflorescence colour, inflorescence shape and growth habit to both parents. It was thought that there should be three colour hues of pink intermediate between ‘Jungle King’ and ‘Jungle Queen’ selected. If there were more, then the differences in hue may be too indistinct - especially as flower colour varied with time of year and age of the plant. All of the seedlings had inflorescences which were an improvement in colour on ‘Eileen McDonald’ although none yielded as high as ‘Eileen McDonald’.

Unfortunately those seedlings which had the most attractive inflorescences also had relatively low yield although vase-life was always good. Because of this a compromise was reached where for each colour hue - light pink, medium pink and dark pink - the plant with the most attractive inflorescence was released as well as the plant with the highest yield. Also, one of the seedlings was almost a bi-colour in that when the inflorescence is observed from above, the bracts appear whitish with a red edge. This plant was released as well.

Advanced Kangaroo Paw Variety Assessment

Project Period : 1992 - 1995  
Project Officer : W Tregea and P Slinger  
Project Location: Ti Tree Research Farm (TTRF)

Objective:  
To select kangaroo paw varieties suitable for both the Australian and export cutflower markets.

Background:  
Variety trials of four varieties have been trailed at TTRF. Three of the four varieties performed well, with yields in excess of 30 stems per plant. These varieties were harvested in October, a month in which there is a high demand for yellow flowered Kangaroo paw in Japan and Europe.

Outside the November to January period, the Australian market is demanding several varieties of kangaroo paw and this market may be able to be met by the Centralian growers.

Export markets in Japan and Europe during September, October and early November, exist for Australian grown kangaroo paw and these markets are growing.
One flower export company has indicated that they may take 2000-8000 bunches per week during this period from Central Australia.

Prices for 100 cm stem length flowers should average $0.50/stem, although several growers have averaged up to $0.75/stem during the 1992 and 1993 season.

**Method:**
The trial consisted of 26 varieties with ten plants per plot in two blocks. Planting occurred on 14 April 1992. Plant spacing of 80 cm within rows and 90 cm between rows were used, row spacing was 3 m. The plants were irrigated with continuous dripline with emitters spaced every 0.4 m with a drip rate of 1.75 L/s. Irrigation was monitored and scheduled by the use of tensiometers.

Each plant received 0.3 g nitrogen and 0.2 g potassium weekly by the application of ammonium nitrate and potassium nitrate.

After harvest the crops were fertilised with iron chelate (60 g/10 m²) and Zinctrac® (600 ml/ha).

Weeds were controlled with chlorthal-dimethyl, napiopamide and mowing.

Insects did not cause any problems, but rabbits and kangaroos need to be kept out of newly planted crops.

**Results:**
The varieties selected for commercial cutflower production had stem lengths over 90 cm, colours of the florets were distinct and vibrant, and the stems were straight, disease and blemish free. Yield of marketable stems was also a major criteria in selecting suitable cutflower varieties for Central Australia.

From this trial and previous variety trials, the recommended varieties to plant in Central Australia for the export cutflower market are:

- **Yellow Flowers**
  - Bush Haze
  - Bush Dawn
  - Yellow Gem

- **Red Flowers**
  - Velvet Harmony
  - Red Cross
  - Early Spring

Flowering of kangaroo paw in Central Australia occurs before any other planting in Australia. This market timing gives Central Australia full potential to exploit all export markets.

Commercial production from Ti Tree is recommended with the above varieties.

Further assessments of new varieties should be done to keep Centralian production in the forefront of Australian production.

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**Floriculture Research in Central Australia**

- **Project Period:** 1989 -1994
- **Project Officer:** W Tregea and P Slinger
- **Project Location:** Ti Tree Research Farm

**Objective:** Carry out screening of native and exotic flower species.

**Background:**
Geraldton wax has been the main crop studied.
Wax plants originate in arid areas of Western Australia with similar climatic conditions to those of the southern Northern Territory. Australian exports average around 6.78 million stems each year. Israel exports three million stems per week from November to April, which gives an estimate to the size of the export market that Australia could have from May to October. Japan is Australia's major market with 95% of the Geraldton wax crop being exported there.

The seasonality percentage of wax flower exports by month are:

<table>
<thead>
<tr>
<th>Month</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>May</td>
<td>0.07</td>
</tr>
<tr>
<td>June</td>
<td>1.7</td>
</tr>
<tr>
<td>July</td>
<td>14.3</td>
</tr>
<tr>
<td>August</td>
<td>23.4</td>
</tr>
<tr>
<td>September</td>
<td>15.3</td>
</tr>
<tr>
<td>October</td>
<td>31.2</td>
</tr>
<tr>
<td>November</td>
<td>13.1</td>
</tr>
<tr>
<td>December</td>
<td>1.0</td>
</tr>
</tbody>
</table>

For Centralian growers to be able to complement the existing export market they would need to produce in May, June, July and September. Although, if the flower colours are produced at different times from those of other Australian growers, production could occur in August and October.

Method:
Western Australian natives were planted at TTRF on 22 September 1989. The plants were irrigated with continuous dripline, with emitters spaced every 0.4 metres with a drip rate of 1.75 L/s. Irrigation was monitored and scheduled by the use of tensiometers.

Leaf and soil samples were collected every year after harvest to analyse nutrient use. After the third year, no fertiliser was applied to the crop as nutrition analysis revealed no difference with yields or leaf samples between fertilised and unfertilised plants. Leaf and soil samples were collected every year after harvest to analyse nutrient use.

Plants were spaced two metres apart within row and three metres apart between rows. Small plants were planted one metre apart within rows.

The experimental design was completely randomised with ten plants per plot.

Results:
The mortality rates on the following plants were very high and none survived the 1993 season.

- **Chamelaucium axillare**
- **Chamelaucium ciliatrum**
- **Chamelaucium megalopetalum**
- **Hypocalymma angustifolia**
- **Hypocalymma robustum**
- **Verticordia chrysanthra**
- **Verticordia mitchelliana**
- **Verticordia monadelpha**
- **Verticordia plumosa**

Mortality was high due to excessive irrigation in the nursery and many failed to establish in the field. The rest of the above species died in the field over the first two years as they could not tolerate the saline and alkaline soil conditions.

Geraldton wax varieties Alba, CWA Pink, Purple Pride and Newmarracarra as well as *Hypocalymma xanthopetalum* performed very well at Ti Tree. The plants showed vigorous growth and looked healthy.
At Ti Tree, Purple Pride flowers late August to early September, followed by Light Pink in early September. CWA Pink flowered early to mid September and Newmarracarra flowered mid to late September. This puts Centralian production after Queensland and before Western Australia.

It was found that Geraldton wax used more water at a depth of 60 cm, so irrigation was triggered when the 60 cm tensiometer reading was 40 centibars.

Weed control at Ti Tree was achieved by mechanical means - mowing or hoeing with a frequency of four times per year.

A ring barking weevil had caused minimal damage in year three. Case moth was observed in year three in low numbers. In year four several bushes were completely defoliated by this pest within seven days of observing its occurrence. The use of a registered chemical easily controlled this pest. Commercial plantings of Geraldton wax will need to be monitored for this pest on a routine basis as it causes severe damage in a short period of time.

The trial has indicated good potential for Geraldton wax growing in the Centre for the export cutflower market. Further studies need to look at other Geraldton wax varieties to determine if flowering can occur in May, June and July.

ANNUAL CROPS

Performance of Watermelon Varieties under Various Irrigation Systems

Project Period: 1993
Project Officer: J D Bright, A Lyon, M D Hoult and M W Smith
Project Location: Katherine Research Station

Background:
A wide range of watermelon varieties are currently grown commercially at Katherine with limited regard for their comparative performance or their most suitable production periods. Watermelons are produced using either drip irrigation with plastic mulch, or solid-set overhead sprinkler systems. The variable costs of drip irrigation far exceed those of overhead irrigation but little is known about the comparative productivity and quality of the two systems. An experiment was undertaken to compare the yield and quality of the six most commonly produced watermelon varieties, grown under both irrigation systems, during the mid-season production period.

Methods:
Six watermelon cultivars were assessed with both overhead and drip irrigation. Cultivars were randomised (3 replicates) within each irrigation treatment. Irrigation treatments were not replicated but were located immediately adjacent to each other on an area of land known to be uniform. Plots consisted of five individual plant sites with 75 cm between plant sites and 4 m between rows. Plots were direct-sown in July 1993 and irrigated in response to tensiometer readings. Overhead and drip irrigated treatments were irrigated independently according to the tensiometer readings.

Results:
All varieties performed well with average marketable production of between 2 and 3 melons per vine, average melon weight of about 8 kg/fruit, and hectare equivalent yields of around 75 t/ha. Red Tiger (Northrup King) was the most outstanding cultivar, both in terms of quality and yield. Fruit were also of a consistent size, shape (elongated) and weight. Hercules was the best of the round melon types, and had thick skin making it suitable for long distance shipping. Warpaint and Allsweet were severely affected by internal fruit splitting.

With the exception of Warpaint, all varieties produced heavier fruit (at least 1 kg heavier) with drip irrigation than they did with overhead irrigation. However, overhead irrigation resulted in around 30% more fruit being
set on vines. The general appearance of drip irrigated fruit was superior in that the fruit were smoother skinned and did not have distinctly flattened bases, which occurred with overhead irrigation. Drip irrigation resulted in a higher harvest index than overhead irrigation, required less irrigation, and produced fruit some three weeks earlier than overhead irrigation. Yields were generally higher with overhead irrigation, and those varieties that performed well under drip irrigation tended to do the same with overhead irrigation.

Drip irrigation, although a more expensive production system (higher variable costs) provides an opportunity for high quality watermelons to be produced during the cooler months at Katherine. For mid-season sowings (August harvest), Red Tiger is the best performing variety.

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**Cauliflower Varietal Evaluation**

**Project Period:** 1993  
**Project Officer:** J D Bright and A Lyon  
**Project Location:** Katherine Research Station

**Background:**
Climatic conditions in the Top-End are marginal for cauliflower production, principally because of warm temperatures during the winter (dry season). When conditions are most suitable at Katherine (May-August), cauliflowers from southern Australia are readily available. However, supply of the local market during the dry season may still be economically viable provided suitable cultivar(s) for the environment can be identified.

**Method:**
Six previously untested cauliflower varieties were planted in 18 plant plots with 2 replicates per variety. Plants were transplanted at a density of 13,600 plants/ha, and harvesting commenced in August (57 days after transplanting). Varieties were assessed for curd colour, tightness, richness, evenness and size.

**Results:**
The growth of all cauliflowers was extremely vigorous, with large healthy leaves that initially wrapped the curd. However as curds developed most varieties did not maintain tight wrapping and curd deterioration resulted. Due to the unusually high minimum monthly temperatures (highest minimum monthly mean temperatures ever recorded for June, July and August) this problem was aggravated, as was curd development. Hollow stem was found in most of the cultivars, possibly as a result of either boron deficiency or varietal susceptibility.

It is recommended that the promising lines (S354 and 2226) as well as other new lines be evaluated further. Of the 6 varieties evaluated, 2226 (Yates) appears the most suitable for more intensive commercial evaluation, having a smooth dome-shaped curd with only slight discolouration.

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**Lettuce Production in the Semi-Arid Tropics**

**Project Period:** 1993  
**Project Officer:** M W Smith, J D Bright, A Lyon and M D Hoult  
**Project Location:** Hersey Farms and Katherine Research Station

**Background:**
Lettuce is grown at Katherine using technology developed by growers through many years of commercial experience. The opportunity existed to examine lettuce growth under these management practices and to identify areas where improvements could be made.

**Method:**
Lettuce plots were monitored at weekly intervals (from sowing to harvest) for soil nitrate, soil moisture and plant nutrient removal. Biomass, leaf number and leaf area were also determined each week. Relationships were developed to explain changes in plant characteristics and nutrient uptake with time. The influence of two different nitrogen sources (ammonium and urea) on plant growth was also determined.
Results:
Limited activity occurred during the first 35 days after sowing, after which light interception, nutrient uptake, and leaf area index increased rapidly. Nutrient uptake occurred at a constant rate up until harvest with nitrogen and potassium being taken-up at highest rates (14.9 and 35.3 kg/ha/week). Nutrient concentrations in the plant fluctuated considerably during the growing season in response to changes in rates of biomass accumulation at constant rates of nutrient uptake.

Ammonium sulfate increased the uptake of magnesium, calcium and boron, compared with urea, which could have important implications for the management of tip-burn in this environment. However, no differences in yield or quality were detected between the two forms of nitrogen for the mid-season planting examined in this experiment.

Opportunity exists to use lower rates of nitrogen than is currently the case, while it may be beneficial to increase the application of potassium and magnesium. Fertiliser practices should ensure a constant supply of nutrients commencing from about 35 days after sowing. Use of ammonium sulfate as a side-dressing (in preference to urea) may help to reduce tip-burn, particularly during warmer periods of the production season.

Legumes for Green Manuring

Project Period: 1993 - 1996
Project Officer: M D Hoult and M W Smith
Project Location: Katherine Research Station

Background:
Legumes currently available for wet season planting are unsuitable as green manure crops because they are slow to establish; have difficulty withstanding dry periods; have low biomass production and; flower too early in the season. A screening program commenced in the 1993-1994 wet season to identify a legume cultivar that could overcome these problems.

Method:
Late flowering seed lines were collected from various plant breeders and seed repositories around Australia and were sown in single row plots of 2 metres length. Flowering date was recorded, and the plots harvested for biomass determination as soon as the first pod reached maturity.

Results:
One very late flowering cow pea was identified and seed is currently being bulked for more intensive evaluation.

Suitable legume cultivars exist that will remain vegetative throughout the wet season, thus enabling high biomass production without the production of seed (which could become a weed in dry season horticultural crops).

Sweet Potato Irrigation

Project Officers: M Traynor, K Blackburn and Y Diczbalis
Project Location: Coastal Plains Research Station

Objective:
To compare drip irrigation with overhead mini-sprinkler irrigation for yield and quality of sweet potato cultivar, NC3.

Background:
Sweet potato has been identified as a crop that could have considerable potential in the Top End although the NT market size is strictly limited. Sweet potato is well adapted to Darwin climatic conditions and could be a small profitable industry as long as yields are above average and prices remain at reasonable levels.
Unfortunately, interstate prices were not good during 1993 with a more regular supply to markets from areas of Queensland and a flattening out of peak prices in previously identified market time slots.

A sweet potato irrigation trial was conducted in 1992 comparing drip tape, overhead mini-sprinkler and overhead solid set irrigation systems on 3 cultivars of sweet potato. Trial data indicated that the irrigation inputs were not managed uniformly over the three irrigation systems and the results were considered inconclusive. Formal monitoring of water inputs during the trial was not carried out so it is difficult to directly compare crop performance on the basis of the irrigation systems. Plants grown under the drip system experienced high soil moisture tension throughout the root initiation and filling period, whereas those grown under the mini-sprinkler system were kept at field capacity. Moisture levels in the overhead solid-set treatment were in between those of the drip-tape and mini-sprinkler systems. Lower yields under the drip coincided with high moisture tensions and dry surface soil, which did not allow the nodes of the spreading vines to set roots, and inadequate nutrition due to fertiliser being spread on dry soil and being unavailable to the plants.

There was not a great deal of difference in the performance of the plants between the two overhead irrigation systems so it was decided to compare one of these systems with drip-tape again under more efficient scheduling practices in 1993.

**Method:**

**Variety:** NC3  
**Trial Design:** CBD, 3 Replicates  
**Plot Size:** 4 Beds per treatment replicate, 10.0 m/bed x 33 plants, (with 2 inside beds using tip cuttings, 2 outside or guard beds using backcuts as planting material) i.e. Total plants per replicate = 132.

**Treatments:**

A: 8" high flow T tape  
1 tape line centrally placed on a raised hill  
2.0 m between lines, 20 cm emitter spacing  
precipitation rate @ 100% ground cover equivalent to 3.1 mm/hr

B: 8" high flow T tape  
2 tape lines, 20 cm apart on top of a raised hill  
2.0 m between sets of lines, 20 cm emitter spacing  
precipitation rate equivalent to 6.2 mm/hr.

C: Overhead mini-sprinklers, Wingfield Challenger, yellow jet, 50 cm above ground  
3.0 m between lines, 5.0 m between sprinklers, square pattern  
Operating pressure 150 KPa  
Measured precipitation rate 7.5 mm/hr.

**Sown:** 28/6/93  
**Harvested:** 9/11/93

The overhead mini-sprinklers gave a complete ground cover of water while the two drip line treatments produced a continuous wetted strip along the raised planting hill. Irrigation scheduling was carefully controlled using percentage ground cover, open pan evaporation and Crop Factor measurements at weekly intervals. Banks of 3 tensiometers set at 20 cm, 40 cm and 80 cm, were installed in each replicate to monitor soil moisture tension and to check on the evaporation replacement, irrigation scheduling procedure. Also weekly readings of all replicates with the neutron moisture probe (NMP) monitored total soil moisture content. The irrigation times for each treatment vary, in the first place between the two drip tape treatments due to the different discharge rates and secondly between the drip tape and the mini-sprinkler treatments due to percentage ground cover differences - the mini-sprinklers cover the entire surface of the ground so irrigation times are not dependent on crop ground cover.
A basal fertiliser application of 50 N, 90 P, 50 K kg/ha was applied to the trial area and two side dressings totalling 50 N + 150 K kg/ha were applied at 4 and 10 weeks after planting. Dry fertiliser was used with the overhead mini-sprinkler treatment but the drip tape treatments were injected with the equivalent rate of KN03 through the irrigation system. A pre-emergent herbicide was not used on the trial so that some assessment could be made of the weed problems under the two basic irrigation systems.

The two centre beds of each four-bed replicate were planted with sweet potato tips which is normal commercial practice. The two outside guard rows, due to a shortage of NC3 planting material, was planted with backcuts or material taken further back along the runner from the tip piece. This practice is not recommended due to delay and no-uniform maturity of the crop from backcut material.

Results:
Although the overhead mini-sprinkler yields were consistently higher than the two drip-tape treatments the difference in marketable and total yields as well as differences in all grade sizes, in all three replicates, were not found to be statistically significant. However, the difference in yields between the two centre rows and the two outer guard rows was significant and this was due to the backcut material used for the guard rows being less mature at harvest than the tip cuttings.

The drip-tape treatments performed very well with correct irrigation scheduling procedures being employed. The average daily pan evaporation, a weekly estimate of percentage ground cover and a Crop Factor were used to determine irrigation run times with the drip-tape. The overhead mini-sprinkler requires only daily pan evaporation as the pattern covers the entire ground surface. A Crop Factor of 0.8 was used for the first eleven weeks when it was increased to 1.0 until harvest at 18 weeks. Both soil moisture tensiometers as well as neutron moisture probe readings indicated that extra irrigation was required at week 11 (Sept. 13). The three irrigation treatments were very similar in terms of soil moisture tension and volumetric soil moisture at the three depth levels. As well, the total soil moisture to 120 cm over the three treatments were very similar indicating careful irrigation scheduling. Much more water is applied with the overhead mini-sprinkler system, especially in the early stages of growth, compared to drip-tape.

Trial observations noted that sweet potato weevil damage was more obvious in the drip-tape treatments where cracks appeared in the dry soil surface allowing entry of the pest. Also, plants in these treatments often appeared to be stressed although sweet potato is renowned for its drought tolerance. Generally, root grades were smaller with drip-tape but were also cleaner roots. There was a noticeable absence of weed problems.

The overhead mini-sprinkler treatment exhibited more vigorous growth and had much larger plants and generally the roots were larger with better shapes and skin colour. There was no evidence of plant stress throughout the trial but weeds were a serious problem.

Discussion:
Trial marketable yields of sweet potato, ranging from 70.7 to 84.1 t/ha, are very high and is an indication of what can be achieved commercially with good irrigation scheduling. Marketable yields of about 30 t/ha are considered to be commercially viable. Drip-tape has many advantages with the most important being yields in terms of capital expended on an irrigation system or kilograms per dollar spent. It can be seen that drip-tape is a very efficient system for sweet potato production.

Other advantages include production in terms of irrigation water used or kg/mm applied and less problems with weeds in the crop. It should be emphasised that fertiliser side dressings after crop establishment must be injected through the drip line as there is insufficient wetted area on the soil surface for broadcast dressing to be used efficiently.

One disadvantage of using drip tapes is the potential, not experienced during the harvest of this trial, for the tape to become seriously entangled in the mechanical harvester. Some system will have to be developed to prevent this from occurring or for removing the tape from the crop before harvesting.

References:
Sweet Potato Soil Insect Control

Project Officers: K Blackburn, M Traynor, S Smith and M Neal
Project Location: Coastal Plains Research Station

Objective:
To evaluate methods of applying chlorpyrifos to sweet potatoes to control sweet potato weevil, Cylas formicarius, and giant termite Mastotermes darwintensis.

Background:
The sweet potato weevil can cause severe economic damage to sweet potato roots in commercial crops. At this stage there is only one commercial grower of sweet potato in the NT and his losses from weevil have been slight but significant. Losses from giant termites have been severe in isolated patches and this can be more prevalent on newer cultivated areas. However, experimental areas at CPRS have suffered substantial damage from both weevil and giant termites. It was considered necessary to evaluate this chemical, which is registered for sweet potato use, to be able to combat future problems with soil insects in any expansion of the present industry. Also, this work is necessary to complete the R & D work that has been carried out over the past 3 or 4 years to develop a package of technology for sweet potatoes.

Method:
Variety: NC3
Trial Design: RCBD, 4 replicates
Plot size: 10.0 m beds, 33 plants
Treatments:
A: Control (2 controls) - no treatment
B: Chlorpyrifos dip of planting material (0.1% ai for 3 mins)
C: Chlorpyrifos dip (0.1%) + foliar spray (0.05% ai) at 10 weeks
D: Chlorpyrifos dip (0.1%) + soil incorporation (2.0 kg ai/ha) at planting

Planted: 20-8-1993
Harvested: 19-11-1993 (at 13 weeks)

The trial beds received a basal fertiliser rate of 48 N, 90 P, 48 K kg/ha with two side dressings at 4 and 10 weeks totalling 50 N, 150 K kg/ha. Overhead irrigation was used and tensiometers in banks of 3 at depth of 20, 40 and 80 cm, were used to accurately schedule irrigation.

The crop was harvested at 13 weeks before it was fully mature (18 weeks) due to a heavy attack by magpie geese which were in uncontrolable numbers. Assessments were carried out by staff of the Entomology Branch and the Horticulture Division on relatively immature roots before the weevil infestation reached significant levels of damage. The trial was established on an old sweet potato area that had been left with residue from the previous year and had a relatively high incidence of sweet potato weevil.

Results:
A single-factor ANOVA analysis indicated that differences in weevil damage between treatments were almost significant at the 5% level. This result indicated that treatment with chlorpyrifos would reduce the level of damage. Dipping of planting material alone was not sufficient to prevent damage and soil incorporation was less effective than foliar sprays of the chemical. The results suggest that dipping of planting material plus foliar sprays at say, 5 and 10 weeks after planting, would most likely achieve adequate control of weevils. The results suggest that treatments had little effect on mastotermes which appeared in isolated areas with damage levels up to 5%.

A further trial to confirm these observations may be conducted during the 1995 growing season.
**Sweet Potato Virus - Effect on Yield**

**Project Period:** 1991 - 1994  
**Project Officers:** M Connelly, M Traynor, B Condé and K Blackburn  
**Project Location:** Berrimah Agricultural Research Centre

**Objective:**
To compare two cultivars of sweet potato inoculated with Feathery Mottle Virus with virus free material.

**Background:**
Plant Pathology staff have been curious for some time about the effects of the Feathery Mottle Virus (FMV) on the performance of the more recently bred sweet potato cultivars. Over the past two years, Horticulture Division in collaboration with Plant Pathology Branch has been establishing a virus-free sweet potato program for the NT and will be maintaining this status with regular virus indexing on a range of varieties.

A sweet potato selection trial in 1992 identified the cultivar, NC3, as the most promising type for Darwin conditions although it was subsequently found that the line was positive for virus and that it had been supplied by the QDPI virus-free program in that condition.

Although the NC3 was tested positive for virus the trial yields were very good and the plants seemed to be unaffected. By late 1992 the QDPI had been able to supply virus-free material to us for bulking up at CPRS. The results of the 1992 sweet potato program raised speculation on the effects of the FMV on the more recent, ex USA cultivars such as NC3, under Top End conditions. As well, very little FMV has been detected in the NT and any positive recordings for virus has been on material imported from interstate where FMV can seriously affect the performance of some cultivars.

**Method:**

**Variety:** NC3 and Rojo Blanco  
**Trial Design:** Non-replicated observation plots  
**Plot size:** Beds 50.0 m long, 50 plants/bed  
**Treatments:** Cultivars  
- NC3 - virus infected  
- NC3 - virus free  
- Rojo Blanco - virus infected  
- Rojo Blanco - virus free  

**Planted:** 17/6/93  
**Harvested:** 28/10/93

The trial beds were applied with a basal fertiliser rate of 48 N, 90 P, 48 K kg/ha with two side dressings at 4 and 10 weeks after planting totalling 50 N, 150 K kg/ha rate. Overhead mini-sprinkler irrigation was used and tensiometers in banks of 3 at 20, 40 and 80 cm depths were used to schedule irrigation. A side graft technique was employed to inoculate healthy plants with FMV which were then bulked up and the tips of these plants used to plant the FMV infected treatments.

**Results:**
The two cultivars, NC3 and Rojo Blanco showed no yield reduction due to FMV infection and indicate that these cultivars have tolerance to the virus although virus was present. The more recent cultivars from the USA have been selected for tolerance to FMV and include the two evaluated in this trial. This trial confirms that our two major sweet potato recommendations have tolerance to FMV, and can survive well with virus infection and show very little yield reduction or differences between root grades.

This work will be written up in more depth by Plant Pathology staff in the near future. The results of this trial would question the validity of continuing with the sweet potato virus-free program but other varieties, that may be grown in the NT in future, may not have the tolerance to FMV that these two cultivars possess.
PERENNIAL CROPS

✦ Varietal Trials in Mango

Project Period: 1990 - 1996
Project Officers: V J Kulkarni and D Hamilton
Project Location: Coastal Plains Research Station, Berrimah Agricultural Research Centre and Private Orchards

Objectives:
Introduce and test performance of new mango cultivars which may have potential in domestic and foreign markets, may have potential as rootstock, in breeding or for extending the fruiting season. To also introduce different species of Mangifera for breeding and rootstock research.

Evolve superior, early-maturing mango cultivars to suit the needs of the Top End.

Identify promising clonal selections of cv Kensington Pride and evolve cultivars similar to Kensington Pride but with better attributes.

Evaluate the performance and acceptability of other cultivars and identify specific needs for their culture and limitations, if any.

Background:
The needs of domestic and foreign markets are different and these may have considerable influence on varietal research.

Kensington Pride has been the cultivar ruling the Australian market. It is obvious that this cultivar will be preferred to the other cultivars. There may be some exceptions to this such as in the following cases;

• Cultivars with fruits similar to Kensington Pride but with improvement in appearance and quality.
• Outstanding eating quality, appearance and lighter productivity.
• When Kensington Pride is not available in the domestic market, i.e., before the beginning of the season, early cultivars have considerable scope. Successful introduction of late cultivars such as Keitt, Kent and Palmer is a good example and can be used to simulate a case for early cultivars for the Northern Territory. Late cultivars are of little value for the Top End not only because of competing supplies from Queensland but also because of the onset of wet weather conditions which accentuate the insect pest and disease problems. There is, therefore, a need to identify/evolve early cultivars suitable for the Top End. Out of season production seems to be possible with some cultivars and deserves to be tested.

For the export market, in addition to seeking improvement in Kensington Pride, it will be equally important to introduce/evolve super types with attractive appearance, excellent taste, freedom from sapburn and other disorders and good shelf life.

Varietal research also aims at introducing cultivars and other species for their potential use in breeding and rootstock research in tree vigour control and tolerance to adverse soil conditions.

Approaches towards varietal research can be discussed in three categories namely, introduction, selection and crossing.

Results and Discussion:

Introduction of new material
During the year, introductions made in 1992 were planted out at Coastal Plains Research Station and a few more
promising ones at Berrimah Agricultural Research Centre. Of these, cv Royal Special has been found to be very precocious and has shown its genetic trait of off-season flowering and fruiting. For the second year in succession, the young grafts have flowered in April and again in October-November resulting in fruiting in early September and again in April-May. Fruit is very attractive and quality is medium with the presence of slight fibre in the flesh but the cultivar has provided a very important source in flowering studies and manipulation of flowering and in breeding. It is proposed to use it in future studies. Some growers have shown interest in this cultivar and a limited number were supplied on request. Important attributes of the 13 new introductions made last year were described in the previous report. During this year, three new cultivars and two species were introduced from India and Malaysia.

Selection
With the objective of obtaining promising types from seedlings of commercial monoembryonic cultivars, seedling progenies were raised from cultivars Alphonso, Carrie, Glen, Irwin, Haden, Mulgoa, Neelum, Sensation, Sri Jaya and Zill. They were planted at Coastal Plains Research Station in the year 1984. Two selections were made in the year 1992 (S 113 and S 86). A total of 52 inferior seedlings were culled out.

S 113, a selection from the monoembryonic seedlings selected in the previous year, was again found to be promising.

Fruits of this selection matured very early in the season (Dry matter of 14 % on 27 September). Although the seedling is a progeny of cv Glen, the fruit resembles Kensington Pride in shape, size and taste attributes. Fruit is very attractive with a red blush on the shoulders. Another attractive feature is that the flesh is fibreless. Taste evaluation by staff and some industry members has given a very favourable opinion. A limited number of scion shoots and grafts were supplied to interested growers. Performance of these will be monitored.

Another selection S 54 from progeny of cv Alphonso flowered very early with fruits reaching dry matter of over 18 % on September 28. The attractive fruits were also very good in quality. Grafted trees of this selection will also be tested for their performance. S 86, a selection made in 1992 for its firm and attractive fruits, matured later than Kensington Pride.

Crossing (Hybridisation)
During the 1994 season, a mango crossing program was commenced as a cooperative program between DPIF (NT), CSIRO, QDPI and WADA. It is proposed to cross Kensington Pride with other cultivars to improve fruit colour and fruit bearing and to overcome limitations such as sap burn. Some combinations are aimed at a dwarf tree form. Grafts of the successful crosses will be planted at different sites in the participating States/Territory. Crossing work was commenced in June 1994 at CPRS. Trees were treated with paclobutrazol in January this year. This treatment has resulted in very profuse flowering in the parents to synchronise with Kensington Pride which is being used as the male parent on account of its polyembryony. The following cultivars have been selected as female parents.

- Keitt
- Haden
- Kent
- Alphonso
- Palmer
- Suvermarekha
- Glen
- Julie
- Tommy Atkins
- Hybrid-10
- Irwin
- Sensation
- Lippens
- Van Dyke
- Hybrid 17-3

It is also envisaged to use cv Royal Special and the new crossing technique developed with this cultivar in future breeding work.

Other, industry-related varietal issues:
One unique development this year is the keen interest being shown by the industry in varietal research. This is a most welcome change not only from the export point of view but also for the long term sustainability of the industry.

There is some concern about orchard management associated problems with cv Irwin, especially its later fruit maturity than Kensington Pride, occurrence of nubbins, fruit deformities and susceptibility to wet weather
conditions. However, some growers have been able to achieve early flowering and fruit maturity by soil application of paclobutrazol and are persisting with this cultivar. In a similar situation, cv Glen which was earlier ruled out on account of its unreliable and shy bearing habit has also responded to the treatment. A large scale trial with this cultivar on a grower property has been very successful for the last three years.

Of the other cultivars, there is interest in cvv Nam Dok Mai, R2 E2 and Florigon. Nam Dok Mai is a compact tree and had ranked as one of the best in a quality evaluation test. It is felt that this cultivar may at times suffer from problems in pollination and fruit set.

Cv R2 E2 is similar to Kensington Pride but fruit maturity is later by approximately a fortnight. Fruit size is very large (around 700 g). The fruit is preferred by Japanese visitors to Queensland. It is therefore tipped as a cultivar with export potential.

Florigon is being experimented by some growers to test its early fruit maturity reported from Queensland.

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**Regulation of Vegetative Growth, Flowering and Fruiting in Mango**

**Project Period:** 1990 - 1996

**Project Officers:** V J Kulkarni and D Hamilton

**Project Location:** Coastal Plains Research Station and Private orchards

**Objective:**
- Improve profitability and sustainability of mango industry by inducing early, synchronous and profuse flowering thereby increasing yield and achieving early fruit maturity and consistent high fruit quality.
- Control excessive tree vigour and to generate information to evolve high density planting (HDP) systems for the Top End and suitable technology for management of HAP mango orchards.
- Understand physiology of vegetative and reproductive growth in mango.

**Background:**
The warm tropical conditions of the Top End are conducive to vigorous vegetative growth but encourage erratic flowering and alternate and erratic fruiting in mango. Kensington Pride is a vigorous cultivar and also suffers from unreliable flowering. Time of panicle emergence has a considerable impact on fruit maturity. Flowering is delayed in unfavourable conditions especially when there is late emergence of vegetative flush during flowering time. Delay in flowering leads to delay in fruit maturity and this can cause severe losses to the local mango industry which relies almost entirely on its earliness in the domestic market in relation to Queensland. A technology which would secure the dual objective of vigour control and flower promotion in this cultivar will therefore be of immense value to the mango industry.

Available evidence strongly suggests that flower initiation involves interplay of flower-promoting factor(s) synthesised in the leaves and flower-inhibiting factor(s) - most likely, gibberellins. Thus, the flowering factors which perhaps follow a cyclic pattern for their synthesis, may remain ineffective in the presence of gibberellins and until such stage as the balance is shifted in favour of the flowering factors.

It should then be possible to counteract the gibberellins with growth regulators known for their anti-gibberellin property.

The triazole group of compounds have been found to be very effective in achieving this objective. In this group, paclobutrazol (eg. Cultar®) has been most effective and is being increasingly used in mango-growing countries. Soil application of this growth regulator has been found to induce profuse, early flowering and control tree vigour in several cultivars including Kensington Pride (see Tech. Bull. 207, 1993).

Earlier field trials laid out in 1986 at CPRS were undertaken with very young (2 year-old) grafts when they were
very small for the spacing (10 x 10 m). We now know that the trees should be allowed to fill the allotted canopy before applying the treatment otherwise yields will be reduced on account of smaller canopies. New trials were therefore started at CPRS and in private properties with older trees or trees planted at closer spacing.

For tree size control, pruning has been followed in temperate trees but in mango, its use is generally restricted to initial shaping and removal of unwanted growth. Earlier pruning observations have shown that branch pruning after harvest can not be employed to control tree vigour. In fact, it led to production of shoot clusters, usually resulted in restoring the vigour and ensured severe losses in yields for at least two years. Shoot pruning before expected time of flowering met with mixed results on account of variation between trees and within a tree. Pruning can be successful if we can create a situation which ensures flowering. In some preliminary branch pruning trials a combination of paclobutrazol and pre-flower pruning was found to be very effective. This observation led to systematic trials on whole trees with the final objective of laying out higher density trials to evolve appropriate technology for such systems.

Results and Discussion:

CPRS Trial on Regulation of Flowering and Fruiting in Kensington Pride
This trial was started in year 1992 with 9 year-old trees of cv Kensington Pride grafted on Sabre rootstock. Treatments included soil application of paclobutrazol and controls. Required volume [7.5 g a. i. of paclobutrazol (Cultar®)] was mixed in one litre of water and applied on 5 January 1993 to the soil below the collar region of the tree. Flowering was recorded on pre-tagged shoots. Dry matter content of the flesh was used to assess fruit maturity taking 14% as the required threshold level.

Paclobutrazol significantly promoted flowering and fruiting. It may be seen from the table that 1992 was an 'on' year and 1993 was an 'off' year. In both years there was a significant increase in the yield as a result of the treatment but the effect was more dramatic in the 'off' year. Another consistent observation was early flowering in the treated trees which resulted in significant gain in fruit maturity.

Paclobutrazol treatment causes reduction in panicle size and number of flowers per panicle. This was confirmed from flower counts taken on 15 pre-tagged panicles in trees at CPRS. The required number of panicles were not available in the control trees. Information from earlier studies was therefore used for comparison. Male and hermaphrodite flowers were counted and simultaneously removed every alternate day after commencement of anthesis. Flower counts in the panicles on the treated trees were indeed very low but interestingly, the proportion of hermaphrodite flowers was very high. Anthesis in panicles on the treated trees was completed within two weeks. In mango, an increase in the number of panicles and the proportion of hermaphrodite panicles are more crucial for higher yields than the total number of flowers per panicle. Paclobutrazol seems to assist in achieving this. Available literature strongly supports this finding. It will be appropriate to further examine paclobutrazol effects on sex determination.

Trials on Combined Effect of Post harvest Application of Paclobutrazol and Pre-Flower Pruning
The hypothesis that once the trees have been induced in a floral mode (by prior application of paclobutrazol), pruning terminal growth will induce bud activity and flowering in the lower shoots was tested in trials with 3 year-old trees at Acacia Hills farm planted at a closer spacing of 7 x 7 m and 9 year-old trees at CPRS planted at 10 x 10 m. Treatments involved application of suitable rates of paclobutrazol in January 1993 and pruning in first week of June. Untreated but pruned trees and unpruned trees served as controls. Observations on flowering and fruiting were made.

Maximum flowering and fruiting was obtained in trees which were treated with paclobutrazol and were pruned later in June. Within two to three weeks after pruning, apical and subapical buds on the pruned + paclobutrazol-treated trees were activated and after further two weeks, panicles emerged from these sites. Flowering and fruiting in control trees and only pruned trees was poor. Flowering and fruiting in treatment 'paclobutrazol alone' was satisfactory but significantly less than in 'pruning+ paclobutrazol'. There were significant differences in the 2.0 g and 1.5 g treatments in respect of flowering and fruiting. A dosage factor seems to be very crucial in the first year of application. Flowering was early in all Paclobutrazol-receiving treatments including the 1.5 g treatment. Adequate fruits were not available from the control and pruned alone treatments for dry matter tests and other aspects of fruit quality but visual observations clearly indicated considerable gain in fruit maturity.
Another interesting effect was on the external fruit colour. Fruits in paclobutrazol + pruning treatment were particularly attractive. Better exposure of the fruit to sunlight and the anti-gibberellin property of paclobutrazol may have been complimentary in colour development. This aspect needs to be quantified in future.

**Effect of foliar sprays of potassium nitrate on flowering**

Trials in the previous years had shown that pre-bloom sprays of potassium nitrate (1 or 2%) did not cause flowering in Kensington Pride. This year the effect of higher dosage was tested. In order to test toxicity effects and to fix the threshold rate, branches of 10 year old trees were selected. Treatments included two sprays of potassium nitrate 4, 6 and 8% at 10 day interval in April. Agral was used as wetting agent and water sprays as control. Six randomly selected branches were allotted to each treatment. Considerable marginal and tip necrosis was observed in 8% followed by 6%. The 4% treatment showed much reduced extent of the symptom at the leaf tip. Interestingly, most of the treated branches flushed profusely in May within three weeks of the second spray and failed to flower.

In the other observational trial, trees earlier treated with paclobutrazol in January were sprayed with potassium nitrate in the first week of June with the first symptoms of flowering and again after 10 days. Potassium nitrate sprays alone served as controls. Two trees were used to tag 30 shoots per tree in each treatment. The only noticeable effect of potassium nitrate was on panicle elongation in the paclobutrazol-treated trees. The treatment did not induce any flowering in trees untreated with paclobutrazol. Similar visual observations were made in private orchards where potassium nitrate alone failed to induce flowering in Kensington Pride. Visual observations however suggest that it may be effective in other cultivars such as Nam Dok Mai. This needs to be examined. It is important to remember that potassium nitrate acts as a dormancy-breaking agent and if trees are treated before onset of flower differentiation, vegetative growth may lead to prevention of flowering. Whether this property of the chemical can be utilised in inducing early postharvest growth is also worth investigating.

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**Rootstocks for Kensington Pride Mangoes**

**Project Period:** 1991 - 1996  
**Project Officers:** M W Smith, M D Hoult, J D Bright and A Lyon  
**Project Location:** Australian Mango Growers, Katherine

**Background:**  
Kensington Pride mango orchards in the NT are now established almost exclusively using grafted trees. Care is taken to select scion material from superior trees, but little attention has been payed to the origin of rootstocks used for grafting. Experiments have been established at Katherine to examine the influence of different rootstocks on the performance of Kensington Pride.

**Method:**  
Nine polyembryonic mango varieties were used as rootstocks with Kensington Pride as the scion. Single tree plots were replicated in 6 blocks.

**Results:**  
Stocks differed in their effect on tree yield and fruit quality.

High yielding rootstocks tended to have high productivity (per unit of trunk circumference) and produce fruit with superior external appearance. Of particular interest was the poor performance of Sabre, which although producing a smaller tree, also had low yields, productivity and poor fruit external appearance.

Large trees are often considered undesirable because of the difficulties envisaged in managing them, hence the search for "dwarfing rootstocks". Therefore, the harvesting rate of different rootstocks was studied by measuring the time required to pick both low and high fruit from each tree in the experiment. It was found that trees grown
on vigorous rootstocks could be harvested faster (kg fruit/min) than smaller trees, and that the high fruit (picked with the aid of a cherry picker) was easier to pick than that harvested from ground level. These results have important implications for the management of orchards in the NT.

Leaf samples collected before and after harvest indicate that rootstocks influence leaf nutrient levels. Further work will endeavour to establish relationships between yield, quality and nutrient levels.

Growers and researchers need to take greater care in selecting rootstocks for Kensington Pride, and should try to identify rootstocks that can improve productivity, quality and efficiency in mango production, under local edaphic, climatic and management conditions.

- - - Mango Varietal/Rootstock Evaluation

**Project Period**: 1992 - 1996
**Project Officer**: M W Smith, M D Hoult, A Lyon and J D Bright
**Project Location**: Australian Mango Growers, Katherine

**Background**: The comparative performance of different mango varieties remains largely unexplored in Australia. Kensington Pride is thought to be an "unproductive" variety particularly in comparison with those of Floridian origin. Experimental work is underway to assess the performance of different mango varieties important in international trade, and to compare the performance of these with Kensington Pride, which is the predominate mango variety grown in Australia.

**Method**: Eight year old mango trees of the varieties Glenn, Haden, Irwin, Kensington Pride, Kent and Tommy Atkins were assessed in the 1993 season. Each of these varieties was grown on two different rootstocks (namely Sabre and Common) with trees spaced at 5 by 13.5 metres spacing. Plot size was four trees (within a row) with each treatment combination (variety/rootstock) replicated 4 times.

**Results**: Yields for treatments in the 1993 season were very similar to those obtained in the 1992 season, with the exception of Glenn which yielded 30% more in the 1993 season. Yields were expressed per centimetre of trunk circumference (a measure of tree size) and showed that Kensington Pride has very low productivity compared with other varieties, despite the fact that yields per tree are comparable. In other words, Kensington Pride does not crop as efficiently as the other 5 varieties. Fruit dry matter sampling showed that none of the varieties exceeded 14% dry matter before the end of October.

Results indicate that Kensington Pride is not an erratic bearing variety and that it may be slightly earlier in terms of harvest times. It does however have low productivity compared with other commercial mango varieties.

- - - Fruit Disorders in Mango

**Project Period**: 1991 - 1995
**Project Officers**: V J Kulkarni and D Hamilton
**Project Location**: Coastal Plains Research Station, Berrimah Agricultural Research Centre and Private orchards

**Objective**: Understand factors responsible for internal and external disorders in mango.

Find preventive and remedial measures for these disorders based on the aetiology.
Background:
Mango fruit disorders can be grouped into two categories.

- **External disorders** such as sunburn, sapburn and other blemishes, deformed fruits, nubbins, improper development of external colour.

- **Internal disorders** such as stem end cavity, jelly seed and improper ripening of fruit.

It is a difficult task to manage disorders unless the causal factors are clearly understood. If we consider factors leading to these, the disorders can be of endogenous origin, i.e., from factors emanating from the tree or from exogenous factors such as environment, orchard management practices and fruit handling. However, it is usually a combination of several factors that leads to these disorders. For instance, the innate, caustic nature of sap of cv Kensington Pride combined with fruit handling practices determines the extent of damage.

Earlier trials and observations have clearly shown that the problem of nubbins (small seedless fruits) in cv Irwin is a result of self pollination. Similarly, occurrence of fused fruits in this cultivar is due to the presence of bicarpellary ovaries. Results with fruit deformity have not been so clearcut as nubbins. Several seedling progenies at CPRS produced deformed fruits supporting the implication of genetic factors. Fruit deformity in this cultivar, however, also seems to be influenced by the environment. The disorder was not observed in varietal collections in Queensland. In the previous year, Irwin trees in a location at Katherine were also free from fruit deformity. It thus appears that fruit deformities are a result of interaction between the genotype and the environment.

In cv Kensington Pride, internal disorders, stem end cavity (SEC) and jelly seed (JS) are of importance. Available literature implicates nutrition and the length of time the fruit is left on the tree before harvest as important considerations. High nitrogen and longer pre harvest life on the tree are reported to be conducive to internal disorders. Observations made in the previous year have shown that fruits harvested late in the season were more susceptible to stem end cavity and jelly seed (Tech. Bull. 207, 1993, pp 51-52).

Results:

**Fruit Deformity**
Fruit deformity in cv Irwin seems to be genetically controlled. As mentioned earlier, all 8 year-old seedling progenies of Irwin were showing fruit deformity to some extent or other. In one seedling, fruit deformity was 100% and very severe for three successive years. In order to test whether any transmissible factors are involved receptor shoots of Kensington Pride were grafted in 1993 onto this tree by veneer grafting. Ten shoots took and have flowered in June 1994 along with the mother tree. Fruits from these induced panicles will be observed for any graft transmissible effect.

**Internal Disorders**
Observations made this year on the trees at CPRS and private orchards confirmed that incidence of the internal disorders increased with delayed harvests.

In order to test the effect of excessive application of nitrogen on internal disorders in Kensington Pride, a simple observational investigation was conducted at CPRS. Nine year-old trees on Sabre rootstock with uniform flowering were used for this purpose. Treatments comprised post bloom application of different rates of nitrogen (urea) to the trees in two equal split doses on 30 June when the trees were in full bloom and again on 9 July. This was in addition to the 2.5 kg of 12:12:12 mixed fertiliser applied post harvest. The fertiliser was raked into the soil and watered in. Incidence of fruit disorders was recorded in fruits pre tagged in August. Fruits were sampled twice, once in the first week of October (14% dry matter) and in the first week of November (> 16% dry matter).

Observations in the first random sampling showed no incidence of internal disorders in any treatment. However, Fruits from the treated trees were more green and failed to degreen on ripening. This effect was consistent and was also observed in the late harvest. Another observation was lack of uniform ripening in some fruits from treated trees. In the late harvests, all treatments recorded significant incidence of stem end cavity and jelly seed.
Delaying the harvest thus seems to have an overriding effect on the proportions of fruits with internal disorders.

It was observed that trees receiving extra nitrogen produced heavy vegetative flush on some branches in August/September. Post bloom vegetative flush has a considerable negative impact on fruit retention and development. Fruit drop was very heavy on these branches.

Observations on post bloom application of nitrogenous fertilisers leads us to question the validity of this practice in view of its possible deleterious effects on fruit quality and fruit retention. More systematic research is needed to analyse this view.

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**Ethylene and Ethephon-Induced Fruit Ripening in Mango**

**Project Period**: 1993 - 1996

**Project Officers**: V J Kulkarni and D Hamilton

**Project Location**: Coastal Plains Research Station, Private Packing sheds

**Objective**: Improve appearance of mango fruits and supply uniform, close to ripe fruits to the market by post harvest treatment of ethylene or the ethylene-releasing compound, 'Ethephon®'. Standardise the treatments for Northern Territory conditions without any economic losses in post harvest storage.

**Background**: Two major factors responsible for downgrading fruit in the market are poor colour development and lack of uniformity in stage of ripening. There is not only variation among the trays in a consignment but also among the fruits within a tray. The role of the gaseous, naturally-occurring plant hormone, ethylene in fruit ripening and degreening is well documented. Exogenous application of ethylene or its analog leads to increased synthesis of the gas from the fruit thus leading to acceleration of ripening. Climacteric fruits such as mango respond readily to the treatment. Ethylene treatment can be done at the packing shed or at the market. The time lag between harvest and arrival at the market is longer for NT and, in these circumstances, treating fruits at the packing shed may be more advantageous than market end treatment. However, ethylene treatment also results in acceleration of fruit softening. It is therefore important to standardise the treatment so that fruits are not damaged due to excessive dosage or duration of exposure.

**Method**: Using ethylene standard and gas chromatography, the injection rate for ethylene was calibrated and standardised at 10 ppm for 24 hours for the cool room at CPRS.

For all trials with cv Kensington Pride, mature fruits were used from trees in the flower-regulation trial at CPRS where date of flowering was monitored from the tagged shoots. Fruit maturity was ascertained by subjecting a sample to the standard dry matter test. Before subjecting the fruits to the treatments, they were desapped for three hours.

For ethylene treatment, the fruits packed in the standard trays were subjected to 10 ppm for 24 hours at 20°C and stored at the same temperature. Humidity was around 85%.

For dipping in Ethrel®, the fruits in plastic trays were lowered in larger containers of aqueous solutions of Ethrel® for two minutes. Agrid® was used as a wetting agent. After the treatment, the air-dried fruits were packed in standard trays and stored in cool rooms at 20°C.

Observations on external colour and degree of softening were recorded on the day of treatment and on alternate days afterwards on a 1 to 5 scale.
Results:

Effect of Lag time Between Harvest and Ethylene Gassing on Fruit Ripening
Harvested fruits were held at 20°C and were gassed for 24 hours on the day of harvest or 1, 3, 5 days after harvest. Approximate number of days (after harvest) for ripening was 10 days in untreated control, 8 if fruits were treated 5 days after harvest, 6 to 8 days if they were treated 3 days after harvest, 4 to 6 days if treated 1 day after harvest and 6 to 8 days if treated on the day of harvest. As expected, delaying ethylene treatment resulted in a corresponding delay in ripening. Interestingly, gassing one day after harvest was found to be better than gassing on the day of harvest. This experiment has indicated that there are clear gains in treating fruits in the packing shed rather than at the market end.

Ethrel Dosage Trial
Mature fruits of cv Kensington Pride were dipped in different aqueous concentrations of Ethrel®, i.e., 0.0 (control), 0.5, 1.0, 2.0 and 3.0 ml per litre. While all Ethrel® treatments accelerated ripening maximum response was obtained with the 3.0 ml treatment.

Stage of Fruit Maturity and Response to Ethylene
In order to test the impact of fruit maturity on response to ethylene-releasing treatments, immature fruits (dry matter <13.0%), mature fruits (dry matter 14 to 15%) and over mature fruits (dry matter 16.0% or more) were dipped in aqueous solutions of 0, 1 and 2 ml per litre of Ethrel®. Fruits for different dry matter treatments were selected from panicles of different emerging dates and tagged at flowering time. Fruit maturity had a significant impact on response to the treatment. Immature fruits required high dosage for maximum response, whereas over mature fruits responded readily even to the lowest dosage. Although immature fruits treated with 2.0 ml developed an attractive colour and fruit softening after 10 days, their TSS values and taste (data not presented) was unaffected and was uniformly very poor. Interpreting these results, it is clear that ethylene can not be used to improve quality of immature fruits. Treated, over mature fruits, on the other hand ripened rapidly. This response can be justified by the fact that senescent tissues are more susceptible to ethylene action. Care has to be taken by using proper and not higher dosages for the mature and over mature fruits. The case of over mature fruits is perhaps not applicable on a commercial scenario but has been used to recognise the importance of fruit maturity which is undoubtedly a major consideration in ethylene application for ethylene-induced fruit ripening.

Other Observations
Limited observations with other cultivars were made. Cv R2 E2 responded readily to gassing and Ethrel® dip but in Irwin, there was little gain.

These trials are preliminary and more trials are required to confirm these findings and to make more detailed studies.

It is also proposed to standardise use of ethephon (Ethrel®) and the step in the post harvest dips where it could be included as an independent dip or preferably combined with other dips without affecting efficacy.

Evaluation of Brazilian Cashew seedlings at CPRS

Project Period: 1990-1997
Project Officers: V J Kulkarni and D Hamilton
Project Location: Coastal Plains Research Station (CPRS)

Background:
Cashew cultivar improvement research in the Northern Territory was initiated in the early eighties at Coastal Plains Research Station (CPRS) with seedling selection research using the limited genetic pool from Kamerunga Research Station, and a few from Thailand and India. In order to obtain more variability and thereby better success, seed material from other parentage was obtained from Brazil and seedlings were planted at CPRS in August 1990. A total of 800 seedlings of 23 parents were planted in the sandy soils at 8 m x 5 m. Parent source and number in each are listed below.
Results:
At the age of two years, considerable variations were already evident in respect of the vegetative and reproductive characters of the seedlings. Evaluation of the seedlings was therefore commenced in year 1992. Vegetative characters included tree form (open or compact), tree canopy shape (conical, dome or irregular), and shoot density (dense or sparse). Flowering characters included extent of flowering (profuse or sparse), duration of flowering (synchronous or staggered) and season of flowering (very early, mid season or late). Yield and nut characters were recorded only for selected seedlings.

Vegetative characters
Most trees (approximately 70% of the total) had open structure and irregular canopy. The compact tree form and the dome shaped canopy, generally associated with this form, were observed in 28% of the population. All the tentative selections i.e., the high yielders, belonged to this group. Trees with open form and irregular canopy were found to be more susceptible to high wind velocity. A considerable number (17% of the total number) were uprooted. An examination of the uprooted trees showed a very limited root mass as compared to the large top. This problem was overcome to a large extent by pruning and staking the tilted trees.

Flowering
The juvenile phase in cashew is very short as compared to most other trees. In year 1992, two years after planting, over 88% of the trees had already flowered to some extent or other. Those which failed to do so, were mostly the ones with open and irregular canopy. Others were the off types - the miniatures with extremely stunted growth habit. Synchronous flowering seems to be desirable and the promising types belonged to this group. Time of flowering had considerable influence on sex ratio and thereby nutset. Some seedlings, especially in the A1A2 group, flowered very early in April but did not set any nuts because the panicles had few hermaphrodite flowers.

Yield and nut characters
These were recorded only in trees which were considered promising. Initially, 24 trees were identified as promising.

Interestingly, most of the high yielders were obtained from seedlings of a single genotype - A2. Seedling A2-5/9 recorded the highest yield (13.7 kg in the third year) followed by A2-5/24 and A2-5/18.

Sensitivity to Endosulfan
Some cashew types were found to be very sensitive to foliar spray of the pesticide endosulfan. A single spray caused chlorosis and defoliation. Recovery, however, was also quick.

Response of defoliated trees to pruning
Shoot pruning on the branches of the defoliated trees to the last mature wood resulted in the production of several axillary shoots, whereas leafy shoots produced only 1 or 2 shoots after pruning.

Discussion:
These observations are only preliminary and obviously we can not draw any conclusions regarding the selections. However, some of the tentative selections seem to be promising and will be followed along with the other progeny.
The seedling collection from Brazil, genetically, represents a heterozygous source and there were indeed large variations. Seedlings derived from A2 were however fairly consistent with regard to tree characteristics and have provided some promising types, with ideal tree form, canopy shape and high shoot density. Some more trees in this group also appear to be promising and may merit consideration in the near future.

One problem encountered in the initial establishment was wind damage to the trees. This was almost certainly due to excessive vegetative growth, disproportionate to the root mass. This limitation is not unique to cashew in the Top End but it is certainly more pronounced. Although this was more pronounced in upright-growing trees with irregular structure, others were not free from it. There is a need to recognise this as a major consideration in young plantations. Future research could focus on establishing appropriate root: shoot ratio. This problem could be redressed by judicious pruning. Initial training is perhaps a very important step in cashew management in the Top End.

Endosulfan-induced defoliation was observed in some progeny but the response of such defoliated shoots to pruning was also interesting. Pruning the defoliated shoots to previous mature wood resulted in profuse axillary growth whereas leafy shoots produced only one or two shoots. This could be attributed to correlative inhibitory effect of the leaves. This preliminary observation may be useful in exploring a different approach to attainment of ideal tree structure.

Tree productivity is a result of genotype, environment and cultural practices to suit the needs of the genotype and environment. If we agree that there are certain specific key parameters which decide tree productivity, it should then be possible to improve the performance by targeting the key parameters. If we agree, for instance, that shoot density is a key parameter affecting cashew productivity, we should be seeking approaches towards improving shoot density of a genotype.

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**Citrus Rootstock Evaluation**

**Project Period**: 1987 -1997

**Project Officer**: G Foord, P Slinger, G Keena, and W Tregea

**Project Location**: Ti Tree

**Objective:**
Evaluate several commonly used rootstocks (ie Rangpur lime, Rough lemon, Emperor mandarin, Troyer citrange, Carrizo citrange, Swingle citrumelo, Cleopatra mandarin and Symons sweet orange) under Minneola tangelo, Marsh grapefruit and Imperial mandarin scions.

**Project Description:**
The trial consists of eight rootstocks with three scion blocks laid out in a randomised complete block design with six single tree replications per scion block.

The trial was planted in 1987. This was the third harvest (six year old trees).

**Results:**

**Minneola Tangelo Scion Block**
Watkins rough lemon, Rangpur lime and Carrizo citrange gave the highest yields. Rangpur lime had the highest yield efficiency of fruit weight per cubic metre of tree canopy with Watkins rough lemon also performing well.

**Imperial Mandarin Scion Block**
Carrizo citrange gave the highest crop yield followed by Watkins rough lemon and Rangpur lime.

Fruit size is an important characteristic in mandarins, this combined with earliness attracts premium market returns. Carrizo citrange produced the largest mean fruit weight of the three highest yielding rootstocks.

General observations indicate a compatibility problem continuing with Swingle citrumelo, Troyer citrange and Carrizo citrange.
Marsh Grapefruit Scion Block
Watkins rough lemon, Carrizo citrange and Rangpur lime had the highest yield respectively. Rangpur lime had the highest yield efficiency of fruit weight per cubic metre of tree canopy followed by Watkins rough lemon and Carrizo citrange.

In all three scion blocks Watkins rough lemon, Rangpur lime and Carrizo citrange consistently gave the highest yields. Rangpur lime continued to give a high yield efficiency. Further assessment of yield, yield efficiency and fruit quality is required before a final evaluation can be made.

Pink Flesh Grapefruit Scion/Rootstock Trial

Project Period: 1989 - 1995
Project Officer: G Foord, P Slinger, G Kenna and W Tregea
Project Location: Ti Tree Research Farm (TTRF)

Background:
Market acceptance of pink flesh grapefruit varieties has increased in recent years. The aim of this trial is to assess the potential of pink fleshed grapefruit in Central Australia. Yield, sweetness, flesh colour and time of harvest are four aspects which will determine the crop's viability.

Project Description:
The trial incorporates four rootstocks (ie. Symons sweet orange, Troyer citrange, Rough lemon and Swingle citrumelo) and three scion varieties (ie. Ruby, Foster and Thompson) with and without mild strain tresteza. These are completely randomised with two replicates.

Results:
At this stage mild strain tresteza had no effect on yield.

By rootstock, Rough lemon gave the highest yield and yield efficiency (fruit weight per cubic metre of canopy). Symons sweet orange also performed well.

By scion, Thompson and Foster had the highest yield, however the smaller tree canopy of Ruby gave it a similar yield efficiency.

Marisol Clementine Mandarin Rootstock Evaluation

Project Officer: G Foord, P Slinger, G Kenna and W Tregea
Project Location: Ti Tree Research Farm (TTRF)

Objective:
Potential exists for commercial development of seedless mandarin cultivars for the early market niche. The identification of compatible rootstocks, their effect on productivity, time of harvest and tolerance to soil and water characteristics in Central Australia is also a priority.

Project Description:
The very early, seedless Clementine cultivar Marisol is planted on five rootstocks (Watkins rough lemon, Carrizo citrange, Cleopatra mandarin, Rangpur/Troyer and C32). They are planted in a randomised complete block design with ten single tree replicates.

Result:
The trial was planted in 1991 and as yet no yield results are available.
Tissue Culture Date Evaluation of Commercial Varieties

Project Period: 1992 - 1995
Project Officers: G Kenna, K Young and S Freeman
Project Location: Arid Zone Research Institute

Objective:
Assess the performance of internationally recognised date cultivars under Central Australian conditions, with regard to potential for commercial development, including the comparison of the performance of tissue cultured palms from England and France with offshoots of the same cultivars from California.

Background:
Importation of offshoots from California has proved to be expensive and has met with mixed results. An alternative is the importation of plantlets produced from tissue culture laboratories in England and France.

There are doubts as to whether tissue culture palms grow and produce fruit true to type to the parent palm. A replicated trial using six cultivars, (Medjool, Thoory, Deglet Noor, Barhee, Zahidi and Khadrawy), both tissue cultured and offshoots, was established in 1989 to assess palm growth, yield and fruit quality and to assess whether there is a risk in using tissue cultured palms for commercial date production.

Results:
Only 15 palms from a total of 34 palms in the trial flowered and cropped during the 1993 season. The palms which did crop included all six varieties, with 10 of the palms being offshoots, 4 tissue culture from England and 1 tissue culture from France.

There were no outstanding differences in growth habit or fruit quality between the various planting materials.

Date Cultivar Evaluation

Project Period: 1992 - 1995
Project Officers: G Kenna, K Young and S Freeman
Project Location: Arid Zone Research Institute

Background:
Assess the performance of four internationally recognised date cultivars under Central Australian conditions, with regard to their potential commercial production. Four commercial date cultivars, Barhee, Deglet Noor, Medjool and Thoory were planted in a random block design at the AZRI in September 1989. The trial consists of 1 datum palm per plot, with 4 varieties in 16 replications. The block is bordered by a total of 44 palms (consisting of 18 Barhee, 14 Deglet Noor, 10 Thoory and 2 Zahidi).

Results:
During the 1993 season only 38% of palms in this trial flowered and carried a crop. The cultivar Thoory had the highest number of palms carrying a crop. Thoory also had the highest yield per cropping palm, followed by Barhee and Medjool.

Tissue Culture Date Evaluation

Project Period: 1992 - 1995
Project Officers: G Kenna, K Young and S Freeman
Project Location: Arid Zone Research Institute

Objective:
Assess the performance of internationally recognised date cultivars under Central Australian conditions, with regard to potential for commercial development.
Background:
There are 19 female and 4 male selections of *Phoenix dactylifera* included in the germplasm collection at the Arid Zone Research Institute. Additional varieties with potential for commercial production in this region are planted as material is sourced and introduced from overseas.

Results:
Six of the female cultivars flowered and cropped in season 1993. They included Dayri, Thoory, Deglet Noor, Bou Skri, Barhee and Halawi.

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Evaluation of a Range of Bunch Covers to Reduce Rain Damage in Dates

**Project Period:** 1992 - 1995  
**Project Officers:** G Kenna, K Young and S Freeman  
**Project Location:** Arid Zone Research Institute

Background:
Rain on date fruit as it nears maturity can cause considerable damage. The skin of the fruit can split or check and in some instances rots may also develop. This can cause fruit quality to be downgraded and may render it unmarketable.

A number of materials have been used to manufacture bags to cover date fruit. These bags are applied over the bunches as the fruit nears maturity. Materials used include shadecloth, banana bags, disposable overall material and muslin.

Results:
No rain was recorded at the Arid Zone Research Institute during the months of January or February, during which time the fruit was reaching maturity. During the harvest period there was no rain recorded. This made the assessment of the effectiveness of the various materials used to protect date fruit from rain damage impossible for this season.

An observation was made that the plastic material used for banana bags caused condensation to form on the insides of the bags, around the bunches of fruit. This only occurred where bunches of fruit on young palms were close to the ground and there was free moisture around drippers.

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Parlatoria Scale Eradication

**Project Period:** 1991 - 1995  
**Project Officers:** G Kenna, S Smith, K Young, S Freeman, T Micklem, B Jones  
**Project Location:** Arid Zone Research Institute

Background:
Parlatoria scale is a pest of date palms in the Alice Springs area. The insect threatens the future viability of the industry as it causes palms to be unthrifty and downgrades or renders date fruit unmarketable. It was introduced into the area on infested material approximately 40 years ago. It is established in a commercial planting of palms at Mecca Date Gardens and at the Arid Zone Research Institute with a small persistent outbreak at Arid Gold Farm at Deep Well.

A serious attempt to eradicate the scale from these commercial plantings was begun in April 1991. The program involves:

- Foliar application of insecticides at three weekly intervals.
- Trunk injections of monocrotophos three and six weekly intervals.
- A combination of foliar application and trunk injections of insecticides.
Removal of dead and unthrifty leaves.
Removal of excess offshoots to increase the effectiveness of insecticide applications.

Regular leaf samples of palms at all locations are taken to assess the effectiveness of the program by monitoring numbers of mature/immature, live and dead scale.

Results:
Scale has not been detected in the Dahlenburg Block since early February, 1993. The number of scale on seedling palm plantings has been reduced considerably. The commercial growers receiving assistance from the Department for scale eradication have also had considerable success.

Effect of Asparagus Crown Depth on Spear Quality and Yield

Project Period: 1990 - 1994
Project Officers: M D Hoult, J D Bright, A Lyon and M W Smith
Project Location: Katherine Research Station

Background:
Asparagus is an emerging commercial crop for the Katherine district. Overseas research had previously indicated that crown depth influences spear quality and size. This project sought to clarify this effect under the semi-arid tropical climate of Katherine.

Method:
A randomised complete block design was employed with three, 20 crown plots of the cultivar UC 157 F1. Treatments consisted of crown depths of 10 cm, 15 cm, 20 cm and 25 cm. Data was collected for marketable, unmarketable and average spear weight for a six week harvest period in late May and June, 1993. Data was analysed using SAS.

Results:
No significant differences between treatments were achieved, for the data presented. These results were consistent with the past two harvest seasons of this trial. This project has been terminated.

Crown depth did not influence reject spear numbers for asparagus, under the conditions of this trial. Whilst not statistically significant there was a trend towards heavier, first grade spears at the deepest crown depth treatment. Optimum mature, crown depth for commercial plantings would be about 25 cm.

Observations on Asparagus Spear Quality and Yield from High and Low Density Plantings

Project Period: 1990-2001
Project Officers: A Lyon, J D Bright, M W Smith and M D Hoult
Project Location: Katherine Research Station

Background:
High density plantings of asparagus could offer the potential for producers to maximise profitability by generating high yields in the early years of planting, comparative to traditional, asparagus plantings. The deleterious affects of high density plantings, in later years, also needs to be considered. This observational trial was established, so as to address these issues.

Method:
Two plant densities were established in large, single plots. The lower density planting consisted of 1.75 m inter-row and 0.25 m intra-row arrangement giving a density of 22 000 crowns/hectare. The higher density treatment was double that of the lower density planting, (ie: 44 000 crowns/ha) and was achieved by employing a double row per bed arrangement. Bed to bed centres remained at 1.75 m, with the double rows within each bed at 0.3
Intra-row spacing was maintained at 0.25 m.

The lower density and higher density plots contained 100 and 200 crowns of cultivar UC157 Fl, respectively. Yield and average, first grade spear weight were assessed.

Results:
Marketable yield was greater for the low density planting, comparative to the higher density planting. Average, first grade spear weight for the lower density planting was heavier than for the equivalent grade in the higher density planting. Data could not be statistically analysed and is presented as observations. Harvesting of spears from the higher density planting was more difficult than for the lower density, given the greater spread of spears across this plot.

Whilst the higher density plot out-yielded the lower density, in the first two harvest years, the reverse occurred for the 1993 harvest season. Average, first grade, spear weight was also greater and harvesting easier, (due to a more concentrated row of spears) than in the higher density plantings. The lower density option appears more promising for future, long-term commercial plantings.

Rambutan Nutrient Requirement and Fertilisation

Project Period: 1992 - 1995
Project Officers: T K Lim, L Bowman, and M Poffley
Project Location: Darwin

Objective:
The aim is to study crop nutrient requirement for the development of sound fertilisation programs.

Background:
Seven rambutan plantings in Howard Springs, Humpty Doo, Acacia Hills, Berry Springs and Middlepoint were monitored over two years for leaf and soil nutrient fluctuations in relation to crop phenology and meteorological parameters. Around 340 leaf and 340 soil samples were collected from tagged trees since 1992 to January 1994. The leaf nutrient data are then subjected to modified DRIS statistical analyses to calculate DRIS norms, DRIS nutrient ratios and modified DRIS indices. The DRIS indices are then used to identify the most limiting elements in samples and together with the other data are then employed for rectification of fertiliser rates.

DRIS is the acronym for Diagnosis and Recommendation Integrated System. It is a powerful, new tool to analyse nutrient imbalances in plants for fertilisation purposes. It uses nutrient relationships and dry matter accumulation to diagnose which element is most likely to limit crop growth and yield.

Results and Discussion:
The modified DRIS analyses reveal that in rambutan nitrogen, potassium, and calcium are the most limiting macronutrients, depending on the stage of the crop phenology, weather conditions and individual orchard cultural practices. In general in 1992 to 1994, potassium and calcium were the most limiting factors in rambutan leaves in January. Much potassium is removed by harvesting fruits from November to January. Potassium is also the limiting element in leaves from July during early fruit set and development where flower and fruit abortion occur. Nitrogen is the most limiting from September to November during fruit development. Phosphorus and magnesium occur in adequate amounts in leaves and do not appear to be limiting factors although the level of magnesium in January is comparatively lower than in other months.

Among the micronutrients manganese occurs in high amounts in rambutan above 100 mg/kg throughout the year. Zinc, iron and boron tend to fluctuate more erratically although they appear to be low around March and November. Levels of chlorine in rambutan leaves were higher generally in 1992 than in 1993 because of the use of muriate of potash as the potassium fertiliser in 1992. Generally, chlorine levels are higher during the Dry from July and peak around September. Rambutan leaves have been reported to be sensitive to chlorine levels above 0.12%.

In rambutan soils, total nitrogen decreases from a high level in January to a low in September. All the other macronutrients, available phosphorus, potassium, magnesium and calcium occur in fairly high amounts in
January. This could be explained by the fresh application of fertilisers around the trees in late December or January. Generally the levels of macroelements in the soil do not fluctuate widely as in the leaves because of the good buffering capacity of the soil. Soil pH and electrical conductivity are also fairly uniform, pH varies slightly from 6.1-6.35 and EC hovers around 0.05 mS/cm.

Based on data from crop nutrient requirement generated from m-DRIS analyses, crop phenology and weather influences, one approach to fertilisation is 4 application schedules, in late January, late March, mid May and end of July/August. Higher rates of an NPK fertiliser should be applied during January. Additional potassium (K) fertilisers should be applied during January and end of July/August schedules. Chloride sources of K fertilisers should be avoided. The rate of N fertiliser should be increased for the July/August application. Calcium and magnesium fertilisers, viz. dolomite, should be applied in adequate amounts during January. Micronutrient sprays of zinc, iron and boron should be applied to coincide with peak vegetative flushing in January, March and May. Growers should remember that rates should be increased in accordance with the increasing age of their tree until around 10 years of the tree bearing life.

To determine adequate rates of fertiliser usage, foliar and soil analyses carried out twice and once a year respectively are recommended, and using the modified DRIS technique, elements limiting crop growth and yield can be determined and adjustments of fertiliser rates can then be optimised.

Phenology, Crop Nutrient Requirement and Precocity Studies on Mangosteen

<table>
<thead>
<tr>
<th>Project Period</th>
<th>1992 - 1996</th>
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<tbody>
<tr>
<td>Project Officers</td>
<td>T K Lim and L Bowman</td>
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<tr>
<td>Project Officer</td>
<td>CPRS, Lambells Lagoon, Berry Springs and Northern Territory University</td>
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</table>

Objectives:
Study crop phenology in relation to crop nutrient and other cultural requirements

Develop a sound fertiliser schedule for the mangosteen crop using the above data

Reduce the juvenile period of the mangosteen and enhance the precocity

Background:
Two bearing 8 year old trees in a grower’s orchard was monitored for phenological growth studies where monthly growth parameters were measured. In addition to the two trees, two bearing trees in NTU Horticultural Block, and four six year old trees in a Berry Spring orchard were monitored for crop nutrient requirement on a bimonthly basis.

Results and Discussion:

Phenology Studies
The tagged terminals of the trees in the grower’s orchard exhibited spurts of growth flushes in late August to October, in late February and early May and remained dormant in the other months from March 1993 till June 1994. Flower buds were observed from late June till late September while flowering occurred from late July till October. Fruits matured from late October to early February but mainly in November to December. The number of days from flower opening to harvest maturity varied from 116 to 125 days.

Crop Nutrient Requirement
This will be reported in the 1995 Technical Annual Report as more data is being accumulated for more meaningful interpretation.

Precocity Studies
In this trial, the following seedling treatments were compared: double rootstocked seedling prepared by inarching and cleft grafting with scion wood from a bearing tree, double rootstocked seedling non-grafted at the top; single rootstock seedling cleft-grafted as above, and seedling with a single rootstocked i.e. non-grafted. Inarching of
seedlings began in early 1992 and grafting was done in the latter half of the year.

The mangosteen plants were planted out at a double-row spacing of 5 m by 8 m and 10 m between twin rows under 60% shade in April 1993. Three months prior to this *Gliricidia* shade trees were established. Development was rather slow during the first few months and during the Dry, growth improved during the Wet especially after March 1994 because of the conducive microenvironment created by the well established shade trees.

The double rootstocked, non-grafted plants exhibited the best mean growth rate of 21.72 cm/ year in terms of height increment, followed by the non-grafted seedlings (16.22 cm/year). Both types produced vigorous primary and secondary branches which were comparatively longer, and the leaves were larger. Both double rootstocked and single rootstocked grafted plants had slower growth rates of 6.5 m/year and 9.97 cm/year respectively. Their branching was minimal and their leaves were smaller and fewer in number this could be due to extensive suckering of the rootstock in the grafted plants.

**Boosting of Durian Productivity**

- **Project Period**: 1992 - 1996
- **Projects Officers**: T K Lim, L Bowman and G Ramsay
- **Project Location**: Darwin

**Objectives:**

Increase productivity by introducing more adaptable, high-yielding durian clones.

Improve our understanding of the reproductive biology of durian with regards to pollination so as to devise a practical means of assisted pollination.

Improve fruit yield by leaf, flower and fruit pruning and proper fertilisation based on soil and foliar nutrient monitoring.

Reduce the juvenile period using various precocious rootstock-scion combinations and propagation techniques with introduced *Durio* species and clones.

This project was funded by RIRDC July 1993 - June 1996 as Project No. DNT 13A.

**Trial 1  Introduction of *Durio* Species and Durian Clones, Germination and Seedling Establishment**

Three hundred durian seeds and 48 grafted durian seedlings comprising 23 different clones were introduced in July in 1993 from Peninsular Malaysia. From the 300 seeds, 270 seedlings were obtained. The grafted durian seedlings did not survive in the quarantine screenhouse after they were fumigated with methyl bromide on arrival by AQIS (Australian Quarantine Inspection Service). A more extensive plant collection trip was made to Sarawak and Peninsular Malaysia from 9 January till 29 January in 1994. Besides *Durio* species and commercial durian cultivars, a total of 440 plants and seeds of 45 plant species were brought back. The following durian plants and seeds were imported into the NT:

- *Durio kutejensis* (durian kuning), *Durio graveolens*, *Durio oxleyanus* and *Durio zibethinus* - cv. DS2, DS13, DS24, DS60, D24, D96, and D99 from Sarawak; and cvs. Ang Bak, Ang Hea, D24, D96, D98, D99, D123, D139, Deka, Holor, Gan Yau, MD 78, MD 79, MD 88, Monthong, and Tawa from Peninsular Malaysia. After special arrangements have been made with AQIS regarding post-entry treatment of plants sensitive or with unknown sensitivity to methyl bromide, survival rates of plants in the screenhouse were much higher. Much more success was found with bringing scionwood for grafting on to rootstock in the screenhouse than with introduced barerooted durian seedlings. The following cultivars are doing well in the post-entry quarantine screenhouse D24, D96, D99, D123, Gan Yau, MD 79 and Monthong, while the rest of the scion buds are still healthy and have started to push.
Trials 2 and 3  Flower Biology, Pollination, Crop Phenology and Cultural Practices

Durian crop phenology studies comprising studies of vegetative and flower flushes in relation to fluctuation in meteorological parameters were initiated in January this year and will proceed for three years to develop a crop phenology model. Studies are being carried out in Berrimah orchard, two growers orchards in Lambells Lagoon and in another orchard in Howard springs. Vegetative flushes and shoot extension were measured every two weeks while flower bud, flower and fruit formation were monitored weekly. Shoot pruning was carried out in January/February and flower and fruit thinning was done during the flowering and fruiting stages.

Additionally, a leaf sampling technique was worked out for durian for the bimonthly leaf and soil sampling of bearing trees to study fluctuations in leaf and soil nutrient levels in relation to different crop phenology phases, weather parameters and crop nutrient demand. This is paramount to the development of a sound and effective fertilisation scheduling for the durian. All data is being downloaded into an Excel database for the development of a DRIS (Diagnosis Recommended Integrated System) fertilisation program.

**Flower Biology**

There were three pronounced flushes of growth as measured by the new vegetative flush and terminal shoot extension from May 1993 to May 1994: 9 September to 6 October; 3 December to end December, and a longer period of 24 February to late April. Preliminary trends in 1992 to early 1994 indicated that flower bud initiation appeared to be induced 10-18 days after the occurrence of 2-3 or more nights of low minimum temperatures of less than 15°C which also varied according to locality.

In 1992, flower bud initials were observed in late May/June in Berrimah and around 25th June in the Lambells Lagoon vicinity and flower buds appeared about 15 July. In 1993, flower bud initials were observed around 28th June at Berrimah orchard and B Lemcke's orchard in Lambells Lagoon. Two weeks later flower bud formation were observed in Siah's and B Jaminon's orchards in Lambells Lagoon and Howard Springs respectively. Flower buds were discerned in the first two orchards around 12 July and a week later in the latter two orchards. Peak flowering from the first batch of flower buds occurred in the first two orchards around mid August and about August 27 in the latter two. In all cases, flower anthesis started about 1500-1800 hr depending on variety.

Thai cultivars like Kampun open around 1500 while for Malaysian cultivars like D24 1630-1730 peak time of flower opening occurred between 1730 - 2000. Anthesis was characterised by the stigma protruding from a small opening at the top of the flower. At anthesis the stigma glistens with liquid - stigma exudate has three functions: the lodging of pollen, pollen germination and nectar reward to visiting insects and bats. Anther dehiscence is characterised by the extrusion of the sticky pollens often in clumps, and lags behind stigma maturity by 3-4 hours, around 1800-1900 hr. Petals drop 15-18 hrs after anthesis followed by the stamens. Before shedding the anthers dry up and the stamens shrivel. Two days after anthesis most floral parts are shed leaving the fertilised ovary and style. Under prevailing Darwin conditions it takes around 110-130 days from anthesis to harvest maturity, fruits dropped on their accord when ready for harvest. Fruit abortion occurred from 1-2 weeks to 75 days after anthesis. In 1993 most fruit abortion was observed around October to mid November coinciding with the hot dry weather.

**Pollination**

Assisted pollination studies started on 14 August and extended to mid September and were carried out from 1500hr to 2100hr. Pollination from 1800hr was conducted with the help of growers. A total of 550 flowers were self or cross-pollinated. Single and reciprocal crosses were carried out among the flowering varieties, viz. D24, D96, Kampun, Lueng, Gob, "Chanee", a Malaysian seedling and an identified Indonesian clone. The best time of pollen collection was determined and a simple method of assisted pollination using pollen laden fine brush attached to a pole was used. Out of the total 300 fruits formed from pollination, a final count of 49 fruits was obtained. Initial results indicated that the Malaysian seedling and cv. Kampun are self-compatible and the rest self-incompatible. Many of the fruits formed by selfing or incomplete pollination were misshapen.

Pollen viability and germination studies were not carried out because of unforeseen renovations of the laboratory at Coastal Plains Research Station which occurred from the end of June to the end of September in 1993.

**Leaf and Soil Monitoring**

Durian leaf and soil nutrient levels were found to be influenced by crop phenological cycles - vegetative, flower and fruiting cycles; weather fluctuations; and farm cultural practices. Based on mean leaf nutrient levels and the modified DRIS indices, it was found that in January 1993, potassium was the most deficient followed by...
nitrogen, and the micronutrients levels of zinc, copper, iron and manganese were also found to be comparatively low. In July to September, leaves were deficient in magnesium and iron and these were also reflected in the patchy chlorotic leaf symptoms. During September to November, i.e. the fruit development stage, nitrogen was the most limiting in the leaves. Compared to rambutan, durian can tolerate higher levels of chloride in the leaves, < 0.2% for the former 0.2 to 0.8% for the latter.

Trial 4 Reduction of Juvenile Period
Double rootstocks were prepared by inarching two closely planted seedlings in a bag. A success rate of 100% was obtained. Topworking seedlings with mature budwood of cv. Kampun onto single rootstocks resulted in only 40% success rate and could be due to the time of the year it was carried out, i.e. in the Dry, from July to September in 1993. No difference in success rates was found between budding and cleft grafting. Topworking of single and double rootstock by bud-grafting with scionwood from bearing cv. Kampun and D24 durian trees during the Wet in 1994 gave 95% success, doubled the success rates of grafting done in the Dry in the previous year. The grafted single and double rootstocked plants are doing well under 40% shade and will be planted out next year in a precocity field trial. Stakes and irrigation lines have been established in the field for the trial and Gliricidia and Inga (ice-cream bean) shade trees have been planted out.

♦ ♦ ♦ Yields of Netted, Trellised and Free Standing Carambola Trees

Project period : 1989-1995
Project Officers: T K Lim and L Bowman
Project Location: Coastal Plains Research Station (CPRS)

Objective:
To compare the yield of netted trellised and netted free-standing carambola

Background:
Previous studies carried out at CPRS since 1989 revealed that carambola trees thrived well in the Top End but economic, productive yield was not attainable because of the ravages by winged vertebrate pests such as the sulphur-crested white cockatoos and bats. Thus, it was essential to net the trees before any yield can be realised.

Results and Discussion:
Results presented herein are based on yield records over the years 1898-1992 of individually netted free standing trees and a netted row of trellised trees. The trellis were of the horizontal type and about 1.75 m above ground level and the trees were planted 2 m apart in a row. Yields of 3 varieties viz. Fwang Tung, Jungle Gold and B16 were compared. The yield records in 1993 were based on netted individual and trellised trees under a large, overhead permanent net structure which was constructed in 1992. Due to disruptions caused by construction and other unforeseen activities, it was deemed that the most valid approach to compare yields between netted trellised and unnetted trees were to use a mean monthly harvest records instead of total yields.

Cv Fwang Tung was the best yielder followed by B16 and Jungle Gold both on the horizontal trellis and as individual trees. Individual trees were more productive than trellised trees on a mean monthly basis. As expected no harvests were obtained when trees were not netted due to ravages mainly from birds, bats as well as insects. The worst offenders were the sulphur crested white cockatoos. Among the insects, fruit flies and fruit piercing moths were the most damaging especially during the Wet season.

On trellis, the peak production periods of the 3 varieties were observed in June, July, August, October and January, while on individual trees, production peaks occurred in April, May, July, August, October, December and January.
Banana Industry Development Program

Project Period: 1993 onwards
Project Officers: K Blackburn and M Traynor
Project Location: Coastal Plains Research Station and growers properties

Objective:
To identify the major issues affecting the NT Banana Industry and then formulate research and development priorities for the industry.

Background:
In early 1993, banana growers from Darwin and Katherine approached DPIF to initiate a banana research program. In the past, DPIF has not been involved in banana research but has provided a service to growers in pest control advice and identification as well as a twice yearly leaf and soil analysis service to all farms.

A "Future Directions" meeting on 6 April 1993, held between grower representatives from the NT Horticultural Association and the Horticulture Division of DPIF briefly discussed proposed banana research and development (R&D) and decided that consultation with the banana industry was the best approach to identifying the issues for an R & D program.

A Banana Workshop was organised and held on 26 August 1993 at Berrimah Farm to discuss industry needs. Two highly regarded interstate banana specialists were able to assist DPIF in the assessment of industry requirements and priorities. Jeff Daniels is the Principal Horticulturist, Bananas, with the QDPI based at the South Johnstone Research Station at Innisfail and Dr Kesi Kesevan is a Senior Research Officer with WADA based at Kununurra. Both researchers visited all farms at Katherine and Darwin and discussed problems with the growers in the week prior to the Workshop being held. They summarised the problems they encountered and nominated areas of investigation as well as discussing developed banana technology that could be directly applied to the NT situation.

Banana Workshop Issues:
At the workshop the consultants emphasised that DPIF should involve staff more with development work based on research work done elsewhere as the best option at this stage and not become involved with large and costly research programs. Briefly, suggested issues for future work include:

- Integration of Darwin and Katherine grants to benefit the Katherine growers from the experienced Darwin industry.
- Study tours for growers to benefit from experience developed in North Queensland and Kununurra.
- Encourage industry co-operation on a national scale.
- Development programs for the banana industry to cover:
  - irrigation monitoring of commercial crops and the use of tensiometers to improve irrigation scheduling.
  - nutrient monitoring to develop diagnostic technology.
- Increase work on insects and diseases with the long term aim of developing Integrated Pest Management strategies and reducing pesticide use. A pest survey on all farms to be conducted initially.
- Introduction of new varieties and banana types for assessment under local conditions.
- Use of tissue culture plants for Quarantine purposes and for increased performance should be assessed.
- Links with researchers in Queensland and Western Australia should be developed and information flow
Potential of the Katherine area for pesticide-free production could be exploited in the future.

Industry representatives were elected at the Workshop to form a Banana Working Group which will meet three times a year in both Darwin and Katherine, to discuss R&D projects and to advise DPIE on relevant industry issues.

**Banana Working Group:**

The Banana Working Group met for the first time on 24 November 1993. The meeting endorsed the findings of the Banana Workshop and discussed in detail the proposed banana R & D programs for Darwin and Katherine. The Katherine program will include screening work to assess cultivars that may be suitable to the cooler dry season conditions experienced there.

By the end of 1993, planning was in place to carry out the major recommendations of the Banana Workshop with most projects to commence early in 1994. The results of this program will be reported next year.

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**Observations of Cupuacu Grown at Coastal Plains Research Station**

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<tbody>
<tr>
<td>Project Officers</td>
<td>P Watson, Y Diczbalis and M Chisholm</td>
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<tr>
<td>Project Location</td>
<td>Coastal Plains Research Station</td>
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**Background:**

Cupuacu, *Theobroma grandiflorum*, a native of Brazil, is seen as a potential cash crop for the Top End of the Northern territory. Its potential lies as a substitute for cacao in the production of chocolate, or, in this case, cupulate. The main advantage over cacao, a close relative, is seen as its habit of dropping its fruit when ripe, which offers the potential for mechanical harvesting. The processed product is also caffeine-free, providing possibilities for niche-market advantage. Seeds were introduced from Brazil in 1991 with the intention of evaluating the crop in the top-end of the NT.

**Method:**

Transplanted to the field in late 1992, cupuacu trees have now been in the ground for one and a half years. Monthly observations have occurred to record plant physical and phenological parameters and to gather information on the pest/disease complex in this environment.

The crop has been irrigated daily, with Soil Volumetric Moisture levels of 400 to 450 mm per 1200 mm of soil depth recorded consistently by Neutron Moisture Probe, and Soil Moisture Tensions less than 200 millibars by Tensiometers, since installation of these monitoring devices in January, 1994, during the wet season.

The fertiliser schedule is listed below:

**Basal**
- 70 g/tree/month NPK (13:14:12)
- 30 g/tree/6 months dolomite

**Foliar**
- fortnightly in 40-50 litres of water
  - 2 g/litre FeSO4
  - 2 g/litre ZnSO4
  - 2 g/litre MnSO4
  - 1 g/litre Soluble boron (separately)

Artificial shading applied at transplanting was removed in early 1993 from cupuacu planted under shade trees (*Gliricidia sepium*). Shades in other rows were removed as they restricted growth and most have now been removed. Severe mealy bug and subsequent black sooty scale, particularly under shade trees, has been ameliorated by removal of every second shade tree (on 30/3/94). These trees were considered to be providing...
the primary source for infestation of cupuacu trees below their canopy, and were also excessively shading.

Growth
Growth, measured by increasing stem diameter and free-standing plant height, has increased linearly throughout the planted life. Free standing plant height has increased over time although inaccuracies occur due to the drooping nature of branches.

Growth rates (stem diameter and plant height), have not been noticeably affected by the removal of shade trees in April 1994, with the possible exception of Row 3, which was the most heavily shaded row, and had the lowest mean stem diameter and plant height throughout most of the period.

Pests and Diseases
Although there is generally some defoliation evident on most plants (perhaps more so than on cacao plants in the same plot and most notably loopers and leaf-rolling caterpillars attacking growing tips), infestations have not been severe, apart from the aforementioned mealybug/sooty scale infestation, of which cupuacu was not the primary target. However, a large number and variety of insects have been observed in the crop.

Phenology
Although the numerical grading system for phenological events needs refinement, flushing occurs from May to October, with sporadic flushes occurring throughout the year.

Flowering, based on only one full year's data, indicates a concentration again from May to October, with sporadic flowering occurring throughout the year. These graphs are based on the percentage of trees exhibiting some flowering at any one time. This can mean the presence of buds, open flowers and senesced flowers individually or, more often, concurrently. Differences between varieties are indicated but not conclusive. On 24/6/94, 70 trees (51%) were at some stage of flowering.

Fruit
Fruitset was first observed in November, 1993, but, as yet has occurred only in a maximum of 7% of trees at any one time, (24/6/94) and on only 15 trees (11%) altogether.

To date, fruit that has matured and dropped has not been retrieved for seed removal in less than two weeks. In all cases, by this stage, fungal invasion has caused seed fatality and in some cases, in-situ germination and subsequent fatality. Pathological identification is being sought, and at this stage the main culprit is likely to be *Botryodiplodia theobromae*, a common tropical fungus with a wide host range (causes stem end rot in mangoes), which infects weakened tissues in hot environments. Regular and frequent harvesting may be required to ensure fruit do not remain on the ground, and on-tree harvesting may be an option, given a reliable index of maturity.

IRRIGATION

Mango Irrigation and Dry Matter Accumulation

Project Officer : Y Diczbalis
Project Location: Australian Mango Growers Pty Ltd, Katherine, Manbulloo

Background:
Mango growers in the NT rely on getting fruit to market prior to the Queensland Industry coming on stream. A major determinant of marketability is fruit dry matter which must be at least 14% before fruit is accepted in southern markets.
Mango dry matter has been shown to be influenced by irrigation management. In a trial conducted at Manbulloo in the 1992 season, dry matter increased as irrigation amount was decreased and irrigation cut off duration increased (Diczbalis et al. 1993). Fruit size was shown to decrease as irrigation amount decreased. The effect of irrigation management on fruit quality (colour development, brix, brix:acid ratio, taste) was not investigated during the trial and is not well understood. Due to the importance of the industry to the NT a further trial was instigated in 1993 to examine the effects of irrigation management on dry matter development and fruit ripening/quality characteristics. The trial was conducted with the help of Australian Mango Growers, at Manbulloo on seedling Kensington Pride trees.

**Method:**
The aim of the trial was to study the effects of irrigation amount and 'cut off' time prior to harvest on the dry matter accumulation of fruit. Treatments consisted of four levels of irrigation inputs (based on levels of evaporation replacement 100, 80, 60, 40%) and four irrigation 'cut off' treatments (4, 2, 1 and 0 weeks prior to harvest). The treatments were applied in combination and replicated twice on a sandy loam soil. Irrigation input treatments were applied from early August, shortly after panicle emergence, until harvest. Fruit were sampled weekly from five weeks prior to harvest until harvest for maturity studies (dry matter, fresh weight, fruit dimensions, flesh colour) and ripening studies (days to soft ripe, weight loss during ripening, peel and flesh colour, flesh firmness, titratable acidity and brix). At harvest, total fruit weight and number of fruit per tree were measured. Soil moisture measurements (neutron moisture probe) were carried out weekly from early August until harvest (early November).

**Results and Discussion:**
Fruit dry matter increased by 1.3 % per week over all treatments, dry matter was higher for the low irrigation inputs. Fruit dry matter reached 14 % approximately 10 to 14 days earlier under low irrigation inputs and early 'cut off' treatments. At the final harvest dry matter increased with decreasing water input and earlier irrigation 'cut off' treatments.

Weight of sampled fruit was reduced by a minimum of 50 gms at harvest by low irrigation inputs (40 %) and early ‘cut off’ dates. Fruit number per tree was unaffected by treatments, hence the reduction in fruit size has large implications on total fruit yield.

Flesh colour at picking was not related to dry matter as per the QDPI Mango picking guide. Flesh remained predominantly white until dry matter exceeded 18.0%. The low irrigation treatment (40 %) delayed peel colour development which resulted in backward looking fruit at the soft ripe stage.

Days from picking to soft ripe decreased as the maturity of fruit increased. Their was a dramatic decrease in the time to ripening between 62 and 69 days following 50% anthesis (18 Oct and 25 Oct respectively). This decrease occurred as dry matter, regardless of treatment, exceeded 14%.

Fruit forced to reach 14 % dry matter by irrigation deficit tended to be of lower quality, particularly if picked at that stage. Dry matter is a less then perfect indicator of fruit maturity, particularly as it was shown to be so responsive to irrigation management. Time from anthesis may be a more reliable guide to maturity, however, it is also susceptible to change due to climatic influences during fruit development. Growers intending to market high quality fruit should consider irrigating at levels in excess of 70% evaporation replacement and allowing fruit to reach a minimum of 15 % dry matter prior to harvest.

**Acknowledgements:**
I wish to acknowledge the excellent cooperation received from Manbullo Mangoes Pty. Ltd, Katherine. I also wish to thank the horticulture staff in Katherine and Darwin for their assistance during the trial.

**Reference:**
Rambutan Irrigation Management and Flowering

Project Period: 1992 - 1995
Project Officers: Y Diczbalis, P Watson and M Chisholm
Project Location: Mr Roy Gubb, Coulton Park

Background:
Rambutans are still a relatively new crop in the top-end of the NT. Most producing trees are less than six years of age and irrigation management has been based on maintaining soil moisture throughout the year without any regard to crop phenology. The growth patterns of the rambutan in the top-end suggest that low night temperatures in June and July cause a cessation in vegetative growth which is conducive to flowering in July to September. This results in fruit being ready for harvest from November to December, which are often low price periods, due to competition with other fruits available on the market at that time of the year. Market information (Landrigan pers com. 1994) suggests that October and late January are more favourable harvest periods in terms of price. Low soil moisture may be another means of reducing vegetative growth and triggering flowering. If so flowering and hence fruiting could be managed more readily.

Method:
A trial was conducted on a commercial property to assess the effect of pre-flowering irrigation management on time and synchrony of flowering in rambutan. Treatments consisted of four levels of water inputs ranging from 122% to 50% evaporation replacement for an eight week period from late April to the commencement of first flower development (early July). Plants were irrigated daily except for the 89% replacement 2nd daily irrigation treatment. Each treatment was imposed on eight plants. Plant growth and soil moisture were monitored twice weekly during this time.

On the commencement of flowering (early July) all plants were watered at a high rate through to harvest. At fruit maturity trees were harvested as the fruit became ripe.

Results and Discussion:
Plants receiving the least water during the pre flowering period, exhibited less vegetative growth prior to flowering and reached peak flowering approximately three weeks earlier than plants under the higher irrigation regimes. This difference in flowering was maintained at the peak harvest stage with the low and high irrigated plants reaching peak harvest on the 23 November and 18 December respectively. Total yield per tree was not affected by treatments, with the average yield being approximately 30.0 kg per tree. Harvest synchrony was improved by the two lowest irrigation treatments, 84% and 72% of the crop was harvested in the first three weeks in the low and twice daily treatments respectively compared to 36% and 58% for the high and medium irrigation treatments. Soil moisture tensions, during the pre-flowering period, in the lowest irrigation treatment at 20, 40 and 80 cm reached 88, 85 and 48 cbars respectively with no signs of physical stress to the tree.

The treatments failed to induce flowering and fruiting outside the normal periods. This may have been due to the timing and length of the pre-flowering stress (8 weeks) in combination with the seasonal conditions at the time. The results, however, indicate that low water inputs pre-flowering can induce earlier flowering relative to wet treatments. Wet conditions may also be used to delay flowering, however, low temperatures in June and July are probably the over riding controller of flowering. More work needs to be done to confirm the outcome of the trial and to study the effects of water stress timing, intensity and duration on flower induction.

Rambutan Crop Water Requirements

Project Period: 1992 - 1996
Project Officers: Y Diczbalis, P Watson and M Chisholm
Project Location: Coastal Plains Research Station and local growers

Background:
The Rambutan is native to Sumatra and Malaysia and evolved in an environment (wet tropics) which has a high, well distributed rainfall and high humidity throughout the year. The top-end environment is classified as monsoonal with distinct wet and dry periods during the year. The dry period (8 months), is characterised by high
evaporation relative to rainfall and low humidity.

The water requirements of tree crops are conventionally calculated by multiplying evaporation (mm/day) by a Crop Factor. The Crop Factor is a measure of the plant water use relative to evaporative loss from an open pan evaporimeter (an instrument used to measure evaporation). In turn, plant water use is a function of plant type, canopy area and the plant growth stage.

Information on plant water use will improve on-farm management of trees and improve irrigation efficiency as well as allow for improved planning.

Method:
Work on measuring rambutan water use in the top-end began two and a half years ago. With the help of a number of commercial producers we have monitored weekly soil moisture, irrigation inputs, maximum and minimum temperature and phenology (growth stage). Root sampling has also been carried out (Diczbalis et al. 1993).

Results and Discussion:
The data collected suggests that the period of lowest water use occurs after the end of the wet season to early flowering. Water requirements increase as fruit development occurs, reaching a peak in the latter half of fruit development. Crop Factors have been developed from this data which can be used to calculate approximate water requirements for trees in the top-end. The lower Crop Factor for the period "end of wet to flowering" is for those who wish to try to promote earlier more synchronised flowering.

Growers must note that the evaporation based system of water requirement is a valid means of assessing water use for the design of irrigation systems for new orchards and for a starting irrigation level in existing orchards. Day to day irrigation management should be carried out using one of the many soil moisture monitoring instruments available, such as tensiometers, neutron moisture probes or capacitance probes (EnviroScan®).

From work conducted on rambutan, we know that the plants have a very shallow root system with approximately 70% of the feeder roots occurring in the top 5 to 10 cm. The root system does not appear to extend beyond the edge of the tree canopy. Photosynthesis studies on plants grown in large pots (200 litres) show that plant productivity falls to near zero within three days of no water and that severe leaf loss will occur within 4 to 6 days of no water.

Hence the points to consider when irrigating are;

- use the crop factors supplied to calculate approximate water requirements.
- maximise the wetted area under the tree (greater than 60% of the canopy area).
- irrigate frequently (daily and possibly twice daily during fruit filling).
- use a mulch to improve water retention at the soil surface
- monitor soil moisture regularly
- monitor soil moisture during the wet; be prepared to irrigate
- monitor watering depth, saturated soil beyond 60 cm indicates watering for too long.

The following guidelines are intended for growers who wish to calculate their own rambutan tree water requirements.

1. Use 7.7 mm/day as an average evaporation rate from April to November, or use your own rate.
2. Use the crop factors supplied in the table below.
3. Measure your average tree radius (Diameter/2).

4. Calculate canopy area as follows:
   - Canopy Area = \(\pi \times (r)^2\)  eg \(r = 3.0\) metres
   - Canopy Area = \(3.1416 \times (3)^2 = 3.1416 \times 9 = 3.1416 \times 9\)
   - Canopy Area = \(28.0\) m\(^2\)

5. Calculate water requirements using the following formula;
   - Eg. Evaporation = \(7.7\) mm/day, Crop Factor = \(0.8\)
   - Water Requirement = Evaporation x Crop Factor x Canopy Area
   - = \(7.7 \times 0.8 \times 28\)
   - = \(157\) litres per tree per day.

<table>
<thead>
<tr>
<th>PERIOD</th>
<th>CROP FACTOR</th>
<th># mm per day</th>
<th>litres/ tree /day</th>
<th>litres / tree / week</th>
</tr>
</thead>
<tbody>
<tr>
<td>End wet to flowering</td>
<td>0.6 - 0.8</td>
<td>4.2 - 5.6</td>
<td>100-134</td>
<td>700-940</td>
</tr>
<tr>
<td>Flowering to early fruit fill</td>
<td>1.0</td>
<td>7.0</td>
<td>168</td>
<td>1,176</td>
</tr>
<tr>
<td>Early fruit fill to harvest</td>
<td>1.2</td>
<td>8.4</td>
<td>200</td>
<td>1,400</td>
</tr>
<tr>
<td>Harvest to end of wet</td>
<td>1.0</td>
<td>7.0</td>
<td>168</td>
<td>1,176</td>
</tr>
</tbody>
</table>

# Based on: Tree Size - Canopy cover 25 m\(^2\), Evaporation = 7.0 mm/day

Reference:

POSTHARVEST RESEARCH

++ Postharvest Browning of Rambutan (Nephelium lappaceum l.) Grown in the Northern Territory

Project Officer : M Landrigan
Project Location: Berrimah Agricultural Research Centre and University of Sydney

Background:
Postharvest research is being conducted by Margaret Landrigan as a postgraduate student under the supervision of W B McGlasson (UWSH), S C Morris (CSIRO), T K Lim (NTDPF) and K S Gibb (NTU).

Rambutan is a comparatively new crop in the NT. It is considered to have potential for export as well as for the domestic market. However, expansion of trade into these markets is limited by the short life of this fruit. The major limitations are browning of the skin and spinterns (small spines on the skin) which is associated with a high susceptibility to water loss and to chilling injury at temperature below approximately 10°C.
This research program has been aimed at understanding and resolving the major postharvest problem of physiological browning that besets the rambutan fruit. This was the final season of study and involved detailed experiments to investigate the biochemical basis of browning, and the examination of packaging systems for their effectiveness.

Most studies of fruit browning have implicated one or all of three factors, polyphenol oxidase (PPO), peroxidase (POD), and their phenolic substrates as having a primary role in processes causing browning, either alone or in combination (Kahn, 1975; Van Lelyveld and De Brun, 1977; Vamos-Vigyazo et al., 1985; Lagrimini, 1991).

In rambutan there is no information on the role of these enzymes and substrates in the browning phenomenon. Since so little is known about these biochemical processes in rambutan and PPO and POD were unable to be extracted successfully from the rambutan pericarp previously, the objectives of this section were to:

1) establish if the uptake of known inhibitors of PPO and POD prevented browning in the rambutan pericarp,
2) identify and quantify the major phenolics present and
3) determine whether there was a correlation between enzyme activity and/or phenolic levels and browning.

It was hoped that these studies of fruit browning at the biochemical level would increase our understanding of the browning processes in the rambutan pericarp.

Enzyme Inhibitor Infiltration Study

Materials and Methods:
Forty eight fruit (cv. R 134) were harvested, divided into 4 groups and 3 of the groups were vacuum infiltrated (65 kPa, for 3 mins) with one of the following treatments: 1) water-control, 2) 0.26 mM SHAM® (PPO inhibitor), (Bulcheli and Robinson, 1994) and 3) 42 U ml⁻¹ catalase (POD inhibitor), (Bostock et al., 1987) and the fourth group received no treatment. Fruit were weighed before infiltration and again after drying to determine uptake during infiltration. The surface area of the dried fruit was divided in half and 10 spintems on one half were bent (not broken) to simulate mechanical damage occurring during harvesting and packaging. Six fruit from each treatment were then stored at either high (95%) or low (65%) humidity and scored for browning every second day. Browning of the spintems was scored on a scale of 1-5 (1=no browning; 5=fully browned).

Statistical analyses involved subjecting data to analyses of variance and where appropriate the means compared using Waller-Duncan’s Bayesian k-ratio at k=100 (Steele and Torrie, 1980). The level of k=100 used here is approximately equal to the p=0.05 level in conventional LSD.

Results:
Firstly it is important to note the uptake of solution due to vacuum infiltration. The uptake of 0.8%, 1.0% and 1.3% for water, SHAM® and catalase respectively, demonstrates clearly the inhibitor was taken up into the peel. All vacuum treated rambutans lost significantly less weight than the controls during the storage period.

Only water infiltration increased browning, the inhibitors browned about the same as the untreated control. Although the effect of inhibitors was just significant with respect to the water controls the effects were not dramatic.

Bending of the spintems had greater influence on browning than storage RH and time in storage. Interaction between enzyme and bending suggests that the effect of infiltration treatments was considerably greater on damaged spintems than undamaged ones. There was little or no difference among treatments in unbent spintems. The interaction between inhibitor and storage RH meant that at low RH all treatments exhibited a high level of browning but at high RH there was a strong treatment effect. Infiltration with water led to a large increase in browning with storage at high humidity. This is reversed to almost the control level of browning with the catalase treatment and completely with the SHAM® treatment.

The third order interactions of storage RH x time x bending showed that the unbent spintems (both in high and
low RH) did not brown until day 6, after which the spinterns stored at low RH started to brown rapidly, while those stored at high RH had minimal browning. Browning increased over time from day 2 for damaged spinterns, but more rapidly at low RH. The interaction enzyme × RH × bending showed the treatment effects were small for unbent spinterns (with a considerable differential due to RH) and large for bent spinterns. With bent spinterns at low RH, the lower browning of the uninfiltrated water control was no longer apparent, while for high RH and bent spinterns the water infiltration caused a large increase in browning, which was reversed considerably by SHAM but less so by catalase.

**Extraction, Purification and Identification of Phenolic Compounds**

Tissue samples used in this study were obtained from freeze-dried skin samples collected from fruit stored at different relative humidities (RH). The ground tissue powder was extracted in 80% methanol according to the method of Rathjen and Robinson (1992). A preliminary clean-up procedure was carried out prior to analysis by HPLC, following the method of Jaworski and Lee (1987) to separate acidic and neutral compounds. The extract was placed onto the cartridge, rinsed with 2 ml water and diluted with 2 ml 80% methanol.

The principal phenolic constituents are not usually present in a free state in nature but more usually as glycosides (Ribereau-Gayon, 1972). Consequently, the samples were hydrolysed following the method of Oleszek et al., (1988). Diluted extracts were incubated with 2 N HCl in 50% methanol for 3 hours at 80 °C.

All solvents were of HPLC grade from Millipore. Deionised water was further purified using a Milli-Q (Millipore Corp., Milford, MA). Phenolic standards (chlorogenic, caffeic, p-coumaric and protocatechuic acids, catechin, epicatechin, catechol and 4-methyl catechol) were obtained from Sigma Chemical Co. (St Louis, MO.)

HPLC separation was carried out on a Millipore Waters (Milford, MA, USA) system equipped with two Model 600A pumps, a Model 600E multisolvent delivery system, a Model 490 programmable multiwavelength detector and a Model 712 autosampler. Resolution was accomplished with a Waters Novapak, 4 μm × 8 mm I.D. Radial Compression column held in a RCM 8x10 cartridge holder with a guard-pak C18 disposable precolumn insert. A modification of the procedure of Bilyk et al., (1988) for phenolic separation involving linear gradient elution was carried out by using solvent A: acetic acid /acetonitrile /water (2.5: 12:85.5) and solvent B: acetonitrile/water (40:60). During analysis the solvent gradient was programmed as follows to give a total run time of 45 min: 0-30 min, 10-100 %B; 30-35 min, 100% B; 35-40 min, 100-10% B; 40-45 min, 10% B.

The flow rate was maintained at 1.0 ml min⁻¹. The UV detector was set at 280 and 254 nm. Three procedures were used in an attempt to identify chromatographic peaks. These were:

1) comparison of retention times of sample chromatographic peaks with those of authentic standards using the same HPLC operating conditions,

2) comparison of wavelength ratios of the absorbance at the 2 wavelengths and

3) comparison of maximum wavelength. P-coumaric acid was used as an internal reference.

**Results:**

The relative retention times of chromatogram peaks of the rambutan extracts were compared with those of standards. The two major peaks in the red rambutan extract did not match with retention times of the standards used. A minor peak had a similar retention time to epicatechin.

A comparison of the maximum absorbance of the two major fractions in the extract with those of the standards was also performed. The spectra of the 2 major fractions from the extract did not match the spectra of the standards. A spectrum of the minor fraction was not performed so a comparison with epicatechin could not be made.

Complex mixtures from natural sources often contain other compounds that co-elute from HPLC columns with compounds of interest and make reliable quantification difficult, hence the use of 2 wavelengths for detection and a comparison of their ratios (Bilyk et al., 1988).
The ratios for the two major peaks did not match with a standard diluting at the same time or with the same maximum absorbance. The minor peak had a ratio of 4.6 suggesting that it could have been epicatechin.

If these compounds were esters of phenolic acids, acid hydrolysis should have cleaved the ester linkage with resulting release of the phenolic acid. Attempts to detect phenolic acids as a product of hydrolysis of the extract however, were not successful. Whilst the retention times of the two major peaks differed from the unhydrolysed sample, the internal standard remained unchanged after treatment. The maximum absorbance wavelengths were similar.

In addition to phenolic, non-phenolic compounds would be expected to contribute to the complex chromatographic pattern. Spanos and Wrolstad (1990) found this in their work on grape fruit juice. Thus, there was the possibility that the two major peaks were not phenolics. However they did appear to be involved in the browning process. Since extractions were done semi-quantitatively a direct comparison could be made between peak areas of the red and brown extracts. The size (area under the curve) of peaks 1 and 2 were both significantly smaller in extracts of brown tissue, as was the area for the minor peak suspected of being epicatechin.

Discussion:
Browning is commonly attributed to a non-enzymic or enzymic mechanism (McEvily et al., 1992), with the polymerisation of endogenous phenolic compounds resulting in the formation of brown pigments.

The studies reported here are the first to analyse rambutan pericarp for enzymic activity and furthermore to examine PPO and POD levels to determine if they reflect the degree of browning experienced by rambutan pericarp. There are various reports of fruits where the degree of browning was strongly correlated to PPO activity whilst other investigations showed a relation between substrate content and browning (Coseteng and Lee, 1987).

The aim of the enzyme inhibitor infiltration experiment was to determine whether infiltration with inhibitors prevented browning. This would then indicate that the enzymes may play a role in the browning process. The uptake of the inhibitors was effective as shown by weight increases following infiltration. Vacuum infiltration slightly increased the occurrence of browning indicating that tissue was damaged during this process. Where spinterns had been bent and stored at high humidity both inhibitors greatly reduced browning. This difference between treatments was not so apparent with the unbent spinterns. One could infer then that the enzymes may be involved in browning in damaged tissue under high RH conditions. At lower RHs this trend may have been absent because desiccation was the dominant browning factor.

The lack of clear results from the enzyme studies may be due to the species of phenolic compounds found in this fruit. HPLC analysis of pericarp extracts of green and red fruit did not reveal significant concentrations of any of the phenols commonly found in fruits. However, two distinct peaks were detected in these extracts both of which were depleted in extracts of brown tissue.

This research has shown that browning in rambutan fruit is complex. Despite the earlier employment of several experimental approaches and biochemical techniques it is still not clear whether browning in this fruit is enzymic or non-enzymic. Underhill and Critchley, (1993) concluded tissue browning in lychee, results from the non-selective browning of a range of cellular products. This appears also to be the case in rambutan. Results in this study suggest that browning in rambutan may have two causes, a large non-enzymic effect due to desiccation at lower that optimal RH (< 95%) and a smaller enzymic effect that only becomes apparent on damaged fruit stored at high humidities for long periods of time. The results do support a low activity of PPO and POD in red rambutan pericarp and further work overcoming the inhibitor/ deactivation problem suggested here and optimising the extraction/ solubilisation/ activation may elucidate the small role played by these enzymes. However, this further research would not seem an easy task. And the results here, clearly show the major cause is non-enzymic browning due to desiccation.

Control Strategies
The structure of the pericarp of rambutans encourages water loss. Water loss can be reduced in a range of fruit
and vegetables, by placing a physical barrier around produce to reduce air movements over its surface (Patterson and Jobling, 1994). The extent to which the rate of water loss is reduced is dependent on the permeability of the barrier to water vapour transfer. The physical barrier may take the form of a package, in which case the ability of the packaging materials to absorb water must also be considered.

Packaging of fruit to limit water loss is commonly used in the horticulture industry (Ben-Yehoshua, 1987; Paull and Chen, 1989; Patterson and Jobling, 1994). Plastic packaging and cool storage combined with a postharvest fungicide treatment has successfully reduced postharvest losses in lychee (Tongdee et al., 1982). However, rambutan fruit are more susceptible to cool storage than lychee and continuous cool storage is not always practicable under commercial conditions. Thus, alternative packaging systems are required to those described previously.

Waxes are often applied to produce, for the two-fold purpose of reducing water loss and therefore the rate of shrivelling, and of improving the appearance to the consumer (Wills et al., 1981). Most citrus fruit are waxed because washing removes much of the natural wax from the peel (Ben-Yehoshua, 1987). Since the physiology of fruit can be affected by wax coatings, the formulation selected must be compatible with each species of fruit.

Chitosan forms a semi-permeable film on the fruit as well as having anti-fungal properties (El Ghauoth et al., 1992). It is a bi-product of the seafood industry and has been used successfully in tomato storage (El Ghauoth et al., 1992). It has also been used as an anti-browning agent in apple and pear juices (McEvily et al., 1992).

In the light of the physiology and biochemistry of rambutan elucidated earlier in this work the aim of this section was to investigate the impact of a range of storage conditions and chemical pre-treatments upon the postharvest life of rambutan fruit. Some novel methods of packaging in combination with dips to control water loss are investigated here. Although wax emulsions for rambutan have been previously investigated new formulations of wax coatings that may provide better control of water loss were examined in the experiments reported here. A range of chitosan formulations were examined for their suitability as fruit coatings also.

Materials and Methods:
In the 1993 season a packaging experiment was conducted to examine in more detail the more successful treatments from the 1992 season. Some modified treatments were also included.

Fruit (cv. Jitlee and Binjai) were harvested at the mature red stage from the experimental orchard at CPRS and dipped in prochloraz (500 ml l⁻¹) before being packed into one of the following treatments (4 replicates for each treatment) and stored at 10°C;

1. Box only
2. Box over wrapped with polyvinyl alcohol (PVA)
3. Box over wrapped with PY-7
4. Punnet only
5. Punnet over wrapped with PVA
6. Punnet over wrapped with PVC
7. AP box 1
8. AP box 2

PVA is a recyclable plastic that absorbs moisture and so does not form condensation on its surface. PVA will expands when it absorbs moisture. When the film dries it returns to its original size.

The AP box 1 packages were similar to the active packaging humidity and condensation control box used in the previous season except they were smaller dimensions, holding approximately 500 g of fruit. The AP box 2 was the same size as AP box 1 but used tissue on the inside and polyethylene as a water barrier. Paper acts as a desiccant and, because the tissue is thinner paper, it should not draw as much water from the fruit.

Fruit were removed after one week and held at 20°C and 65 % RH. Assessments were made on the day of removal and 3 and 6 days after removal. Assessments included measurements of weight loss, the colour of the fruit (Minolta colour meter) and subjective browning scores of the skin and spinterns (1-5: 1=no browning/rots; 5=fully brown/rotted).
Effect of fruit coatings on fruit storage
The effects of three wax formulations on postharvest quality of rambutan were examined in 1993. The waxes (Decca Lustr®, Peach Nectarine Plum Lustr® and Vegetable Lustr®) were supplied by Dr Cliff Daly, Elf Atochem North America ,Inc., California. The waxes were applied at a dilution of 1 part to 6 parts water.

Fruit of the red cultivar R 134 were harvested from CPRS, dipped, and stored at 20 °C and 65 % RH. Each treatment had 3 replicates of 4 fruit. Assessments were made progressively for 10 days. These included weight loss, skin and spintern browning, rots (using a subjective scale 1-5: 1=no browning/rots; 5=fully brown/rotted) and objective colour readings using a Minolta Chroma meter CR-300® (Japan).

Chitosan
The effects of applying several formulations of chitosan were examined in 1993. The chitosan formulations were supplied by Mr Werth, Tobiasen Central, Wisconsin.

Fungicide Treatments
The use of high humidity storage and temperatures above 5°C necessitates the incorporation of fungicides to control pathogens. In this experiment two fungicides were evaluated; prochloraz marketed as Sportak® by Schering Pty. Ltd. and benomyl marketed as Benlate® by Du Pont. The fungicides were applied by dipping or spraying. Fruit (cv. R 134) were harvested from a commercial orchard, treated and then stored at 20 °C, +90 %RH and observed at 1 and 4 days after harvest. The treatments (3 replicates of 4 fruits) were as follows;

1. water dip
2. water spray
3. prochloraz (.450 g l⁻¹) dip
4. prochloraz (.450 g l⁻¹) spray
5. prochloraz (.900 g l⁻¹) dip
6. prochloraz (.900 g l⁻¹) spray
7. benomyl (.500 g l⁻¹) dip
8. benomyl (.500 g l⁻¹) spray
9. untreated control

Where fungal infections of fruits did occur, isolations and identifications were made. The isolated fungi were not tested for their pathogenicity on the fruit.

Statistical analyses
Statistical evaluation of all results was conducted by analysis of variance and where appropriate means were compared using the Waller-Duncan's Bayesian K-ratio LSD at K=100 (Steele and Torrie, 1980). The level of K=100 is approximately equal to the p=0.05 level in conventional LSD.

Results:
Packaging
In the 1993 season, fruit were stored for 1 week at 10 °C and then kept at 20 °C and 60 % RH, to stimulate supermarket conditions. Weight loss increased over time and was different between treatments. Weight loss after 1 week was greatest in the box treatments whilst the covered punnet treatments performed as well as the active packaging treatments. These trends were not reflected in the skin and spintern browning scores. No differences were found among treatments with the objective colour readings, showing that these readings were not as effective as the subjective scores in detecting differences. Rots showed a slight increase with time and by 2 weeks had reached a score of approximately 2, indicating that about one third of the surface of the fruit had browned due to microbial infection. This observation was consistent among all treatments.

Effect of fruit coatings
In the 1993 season, two of the wax treatments significantly reduced weight loss during storage. All of the wax treatments reduced skin browning (p<0.01) but only the Peach Nectarine Plum Lustr (202)® and Decco (251)® reduced spintern browning. Changes in the objective colour measurements showed similar trends to those for browning. The L* value gives an indication of the brightness of the colour and the a* value the redness. L*
values were consistently lower for the untreated control fruit and the vegetable lustr (255) but the differences were not as great as for the a* values. By the final day of storage rots were above commercially acceptable levels (>2.5) in all treatments.

Although at least two of the waxes gave a significant improvement in storage life of rambutan fruit the increases were not useful commercially. A browning score greater than 2.5 is commercially unacceptable. Improved skin coatings and low storage temperatures may be required to give commercially useful increases in storage life.

Chitosan treatments
In the 1993 season none of the chitosan formulations had any effect on weight loss. There was, however, a significant difference (p<0.01) among treatments in skin browning. Fruit in the chitosan treatments C2, C3 and C4 did not brown as severely as the control fruit. The trend was the same for spintern browning although the differences were not as great. The trends in the data for the objective colour measurements were similar to those for the browning scores. L* values were consistently lower for the untreated control fruit but there were no significant differences for the a* values. All of the chitosan formulations reduced the occurrence of rots during storage.

As with the wax formulations whilst some of the chitosan treatments had potential, a more suitable formulation or a combination of postharvest treatments e.g. fruit coating and low storage temperature, may be required to improve storage life.

Fungicide treatments
A range of organisms were isolated from treated and untreated fruits. The most prevalent being Colletotrichum spp. and Pestalotiopsis spp. Neither of the fungicides or methods of application was entirely successful in controlling rots. There are probably several reasons why the fungicides evaluated in this experiment were ineffective. More work is required to develop fungicide treatments for the control of diseases in rambutan fruit.

Discussion:
Rambutan fruits have some unique storage problems because of their structure and high capacity to lose water and because, like most other tropical fruits, they are susceptible to chilling injury. Packaging must serve to protect the produce from mechanical injury and also to ensure that loss of quality can be minimised during transport and marketing.

A high humidity system was the most successful method for reducing weight loss and consequently, browning. Ideally a punnet system, or for the European markets where disposal of waste is a specific requirement, the recyclable active packaging boxes may be ideal. At high humidities and with long storage times, it is most important to control temperature, maintaining it as low as possible to control rots but high enough to preclude the development of chilling injury. A more appropriate protocol to control rots may also be required.

The relative ineffectiveness of skin coatings may be due to the susceptibility of the spinterns to rapid desiccation. Because of the structure of the fruit it may be difficult to achieve a continuous coverage. This was found to be the case when wax coatings were applied to lychee fruit (Underhill and Simons, 1993).

WINGED VERTEBRATE PEST RESEARCH

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Feeding Behaviour and Fruit Preference of the Rainbow Lorikeet

**Project Period:** August - September 1993

**Project Officer:** D Marcsik

**Project Location:** Flight-pens, CSIRO Berrimah

**Objective:**
Investigate the feeding behaviour of rainbow lorikeets and to understand how it influences their preference for particular fruits.
Background:
Rainbow Lorikeets (*Trichoglossus haematodus*) are primarily blossom-feeders, but occasionally they eat insects and fruits. The nectar and pollen harvested from the blossom provide a source of carbohydrate and protein. Nectar unlike pollen contains simple soluble sugars such as glucose, fructose and sucrose which is a good quick energy source required by active birds. Lorikeets have a tongue covered with brush-like papillae for mopping up food from flowers, and a protracted thin-walled stomach for ready digestion (Reader’s Digest 1988). This suggest that lorikeets may have the ability to recognise different substances, and as a result be selective in what they eat.

Method:
Twelve rainbow lorikeets were housed in two flight-pens (cage size 4m x 4m x 2m) each containing 6 birds. A choice experiment was conducted where lorikeets were presented with a number of different test foods. These were pawpaw, carambola, guava, rollinia and snake bean which were selected on the basis of their seasonal availability, and have been known to experience significant bird damage (Lim et al., 1993).

All birds were exposed to each test food in a number of choice combinations and a visual assessment on the level of damage was recorded after 4 hours.

Results and Discussion:
The most preferred test food was pawpaw followed by guava, rollinia, carambola and snake bean being the least favoured. Lorikeets tasted all test foods initially when placed inside the cages and then selected the one they most preferred. In repeated feedings the birds were observed to do the same again and each time chose the most preferred food which recorded the highest level of damage. Therefore, fruits which were preferred contained sugars which the lorikeets could taste. Similarly, fruits which were least preferred were rejected probably due to the unpleasant taste the lorikeets experienced.

In this feeding test, lorikeets selected for fruits which contained a high composition of sugars (ie. pawpaw, guava). The fruit handling technique of lorikeets allows them to taste the fruit juices and detect the sweetness of the fruit. The same technique is used for selecting fruits which are unfavourable such as carambola and snake bean. The carambola fruit contains calcium oxalate which leaves a dry astringent feeling in the mouth when consumed in large amounts. Snake bean is a member of the Leguminosaee family which contains a number of toxins (ie. cyanogenic glucosides) and is unpleasant both to humans and animals in some cases. These could be the unpleasant tastes lorikeets might be experiencing when they eat these foods.

It was also observed that lorikeets had to bite into the fruit to be able to taste it. Initially, the tongue of the lorikeet touches the surface of the fruit then the beak bites into the flesh and extracts a piece and macerates it, thereby releasing the juice onto the tongue. The solid bits are not swallowed but discarded. Fleshy-skinned fruits are eaten this way (ie. pawpaw, guava) but in hard-skinned fruits the surrounding skin is bitten and removed, and only the flesh inside is ingested (ie. rambutan).

Assessment of Several Bird Chemical Repellents and Other Chemicals and their Level of Repellency and Persistency

Project Period : September - November 1993 and March - May 1994
Project Officer : D Marcsik
Project Location: Flight-pens, CSIRO Berrimah

Objective:
Assess and select promising avian chemical repellents which show a significant degree of repellency and persistency.

Determine the rates at which these chemical repellents are most effective.

Investigate the degree of repellency of these chemical repellents on a range of fruit crops.
Background:
Bird damage on fruit crops is still one of the main problems facing growers. Protecting fruit crops has been an important area of bird control studies to reduce damage and achieve minimal fruit loss. Chemical repellents are one of the control measures used for this purpose in such crops as grapes (Rooke 1984, Tobin 1985), cherries (Tobin et al. 1989, Askham 1992), blueberries (Conover 1985, Avery 1992), and figs (Crabb 1979).

This investigation reports on the effectiveness of a number of chemicals trialled on rainbow lorikeets in flight-pen studies.

Method:

Experiment 1
Seventeen different chemicals were chosen for investigation. Both groups of six rainbow lorikeets (Trichoglossus haematodus) in flight-pens received 4 pieces of fruits (ie. pawpaw and guava). One group received two fruits treated with one type of chemical, and the other group 2 fruits with another type of chemical for each day. Each chemical was tried twice on different days. A standard minimal rate was chosen for each chemical.

An assessment of the level of damage for each treated fruit was done 2 and 6 hours later to determine the degree of repellency and persistency. Both groups of birds were monitored for the first 60 mins for any display of dislike, discomfort or sickness to the treatments.

Experiment 2
Six chemicals from experiment 1 were selected and further investigated at different rates. These chemicals showed a significant degree of repellency and/or persistency and were tested on both fleshy- and hard-skinned fruits (ie. pawpaw, guava, rambutans). Both group of lorikeets received the same chemical at one rate in a no-choice test and each rate was repeated twice on different days. The same assessment and monitoring procedure was carried out as in experiment 1.

Experiment 3
A group of ten birds in one flight-pen were selected to try a number of different natural chemical compounds. These were carambola juice extracted from both green and ripe fruits, garlic both fresh and dehydrated, and oxalic acid in the analytical form. Two mixtures were made for each treatment one with 1 litre of water only, and another with 1ml of DC Tron added into the mixture. The same assessment and monitoring procedure was conducted and each treatment was repeated twice on different days.

Results and Discussion:
The level of effectiveness relates both to the degree of repellency and persistency. Methiocarb had the highest level of effectiveness and caused symptoms of post-ingestional illness (ie. weakness, loss of coordination, salivation, vomiting, loss of appetite). The birds which were sick were able to detect the presence of methiocarb in repeated feedings by displaying symptoms of dislike such as head shaking, beak wiping and some salivation. Similar results of post-ingestional illness were also observed when the birds fed on fruits treated with Avitrol® and they showed the same dislike in repeated treatments.

The effectiveness of some chemicals showed a significant degree of repellency initially, but this did not last due to lack of persistency. These chemicals were MA, DMA, DCT and fenthion. Lorikeets detected the presence of these chemicals when they started to handle and bite the treated fruits and displayed symptoms of dislike. The lorikeets could also detect other chemicals on the surface of the treated pawpaw and guava, however, these chemicals did not cause much irritation (ie. vanillin, emetine, cinnamic alcohol). Five chemicals had no affect at all (ie. lithium chloride, benzoic acid, bioshield, calcium hydroxide and alpha-chlortolose).

Significantly different results were recorded for the 6 chemicals tested at various rates on fleshy- and hard-skinned fruits in experiment 2. The rates for MA, DMA, DCT, methiocarb and fenthion used in experiment 1 that were applied to rambutan did not prevent the birds from continuing to eat. However, methiocarb at 4.0 g was very effective on rambutans and the birds experienced some post-ingestional illness after feeding. In repeated tests the birds displayed similar symptoms of dislike when biting off the skin. At the same rate on pawpaw and guava the birds which consumed more of the treated fruits became sick much quicker and violently ill with one death.

Avitrol® tested at the higher concentration was found to be lethal to lorikeets when tried on pawpaw and guava.
Birds showed extreme symptoms of post-ingestional illness and appeared to be suffering much pain and discomfort. They recovered slowly after this treatment. One bird died from this treatment and further test on Avitrol® were stopped.

MA and DMA was found to be phytotoxic to rambutans at the higher rates. Treated rambutans turned black from the effects of both chemicals. Blackening was accelerated when the fruits were exposed to sunlight. Lorikeets did not eat the rambutans when they were black. There was no sign of phytotoxicity on the pawpaw and guava treated at the same rates with MA and DMA. Lorikeets showed a stronger dislike to MA than to DMA on treated fleshy fruits. For DCT and fenithion the level of effectiveness was significantly better at the higher rates on rambutans. Lorikeets displayed dislike to the presence of these chemicals soon after handling the fruit. The degree of persistency was much higher on the fleshy-skinned fruits than on rambutans.

Rambutan fruits treated with carambola juice extracted from both green and ripe fruits did not repel lorikeets, and the same response was observed with DCT added to the mixture. The oxalic acid treatment had no effect on the lorikeets and all treated rambutans were damaged. Lorikeets responded initially to rambutans treated with garlic by displaying symptoms of dislike but once the skin was removed birds fed on the flesh inside and were not affected by the garlic.

The results of this study indicate that for a chemical to be repellent to birds it has to have a mode of action which acts either by taste cues or post-ingestional cues. Also, findings indicate that for the same chemical to have an effect on lorikeets the rate has to be higher for fruits which have a hard skin compared to fruits with a fleshy skin where only half the rate is required in some instances.

### Conditioned Avoidance Learning by Rainbow Lorikeets to Methiocarb

<table>
<thead>
<tr>
<th>Project Period</th>
<th>March - April 1994</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Officer</td>
<td>D Marcsik</td>
</tr>
<tr>
<td>Project Location</td>
<td>Flight-pens, CSIRO Berrimah</td>
</tr>
</tbody>
</table>

**Objective:**
This study was conducted to determine whether or not:
1. methiocarb in combination with DC Tron is more effective than just methiocarb alone;
2. Rainbow lorikeets can discriminate between rambutans untreated and treated with methiocarb + DC Tron; and
3. Rainbow lorikeets would be repelled from treated rambutans by conditioned food aversion learning.

**Background:**
The Rainbow lorikeet (*Trichoglossus haematodus*) is becoming a pest of economic significance in Darwin because of the considerable damage it causes to ripening rambutans. An effective method of control is needed to reduce this damage and chemical repellents such as methiocarb (4-methylthio-3, 5-xylyl N-methyl carbamate, Mesurol®) might provide a way of controlling losses with minimal adverse impact on bird populations (Tobin 1985).

The approach of this study was to determine whether Rainbow lorikeets could develop a food-aversion learning associated with post-ingestional sickness to food treated with methiocarb.

**Method:**
Ten birds were randomly selected and placed in individual wire cages (cage size 61 x 61 x 61 cm) and allowed 2 weeks to adjust to the new conditions. During this period the birds were fed daily with half an apple and orange given to them in the morning. Immediately after the adjustment period the following trials A, B and C were conducted over a 3 week period.

In all 3 trials, solutions of methiocarb were made up for each treatment. Whole rambutans were then dipped in a treatment solution for 1 min and removed, and placed directly inside the selected bird cage. Control rambutans were dipped for 1 min in 1 litre of water only. For all three trials a feeding experimental regime was followed and consisted of 60 mins of test feeding, 60 mins for recovery, and another 60 mins of the same test feeding. During the test feeding and recovery periods observations were made for any signs of dislike, discomfort or
sickness. After each test feeding rambutans were removed and an assessment of the level of fruit damage (%) was recorded.

The methiocarb product used was Mesurol 750® (Bayer Australia Ltd.), a wettable powder containing 75% methiocarb. DC Tron NR is a product by Ampol and is used both as an insecticide or as an adjuvant for other pesticides.

**Trial A:**
Four different treatments and a control were assessed in a no-choice test. These were methiocarb (ME) 1 g/L, DC Tron (DCT) 1 ml/L, ME 0.5 g/L + DCT 1 ml/L, and ME 1 g/l + DCT 1 ml/L. Birds were randomly chosen with 2 birds receiving the same treatment. All treated rambutans were placed in the food dish positioned on one side of the cage with the water dish positioned on the other side. The position of the food dish was changed around each test feeding.

**Trial B:**
Two different combinations of ME + DCT were assessed in a 2-choice test. These were ME 1g/L + DCT 1ml/L and ME 2g/L + DCT 1ml/L. Five birds received one treatment and the remaining 5 the other treatment, as well as, untreated rambutans. The water was removed from the dish and by the toss of a coin the position of the treated and untreated rambutans was decided for each cage. Following every test feeding the positions were changed around.

**Trial C:**
In a no-choice test all birds were given rambutans treated at the rate of ME 2g/L + DCT 1ml/L. The position of the rambutan inside the cage was chosen by the same procedure as in trial B and the water dish was removed.

**Results and Discussion:**
In trial A the level of damage for rambutans treated at ME 1gm and ME 1gm + DCT 1ml was significantly less after the second test feeding, when compared to the first test where damage was greater than 50%. In the first test feeding the lorikeets showed no initial response when handling the treated rambutan. However, after 30 to 40 mins birds which received the ME and ME + DCT treatments showed symptoms of dislike and discomfort (ie. head shaking, beak wiping, salivating) and stopped eating. Some of the birds continue to eat again, but a few did not and looked ill. The lorikeets appeared able to detect the methiocarb in repeated feedings when they handled the treated rambutans, and responded by showing dislike and did not continue to eat. After 3 repeated feedings the level of damage was significantly lower for rambutans treated with ME only and ME:DCT (ratio 1:1) when compared with the other treatments.

In trial B the water dish was removed because none of the birds during trial A were seen to consume water. In the first experimental feeding regime all birds went to the side of the cage where the feeding dish is usually placed and started to feed on the rambutan. Birds which were feeding on treated rambutans started to show signs of discomfort after 30 mins and stopped eating, and later went to the other dish and started feeding. By the end of the test feeding none of these birds were seen to return and feed on the treated rambutan. Birds which had the untreated rambutan in the food dish completely ate the fruit and straight away started to feed on the untreated rambutan in the other dish. Most birds did not stop eating until they started to experience some discomfort and after 60 mins the level of damage for treated rambutans ranged from 20 to 50%. In the second test feeding the position of the two rambutans were changed and most of the birds went to the side of the cage they recognise as the food dish and started to feed. After 10 mins into the test feeding 80% of the birds were feeding on the untreated rambutans and only 2 birds continued to feed on the treated rambutans. These 2 birds stopped eating once they started to experience discomfort and later started to eat the untreated rambutan. The trial was repeated 4 times and the average level of damage for untreated rambutans was 100%, compared to the average level of damage for the treated rambutans which significantly decreased from 50% to no damage. The rate of ME + DCT at 2:1 reduced the level of damage and repelled the birds earlier than at the rate 1:1.

In trial C the birds started to feed on the treated rambutans, and after 20 to 30 mins about 60% of the birds started to show discomfort and stopped eating and later develop postingestional illness. Two birds were observed to completely eat the treated rambutan and did not show any symptoms of sickness. The level of damage ranged from 20 to 100% in the first feeding regime and this dramatically decreased by the next feeding regime from 50% to no damage. The lorikeets were observed at the beginning to feed on the treated rambutan, but when they started to experience symptoms of dislike and discomfort they discontinued eating.
Preliminary results from the following study indicate that lorikeets can form a reliable methiocarb-induced food aversion after they ingest an amount of methiocarb that causes them to become sick. From these preliminary findings in controlled experimental conditions it may be suggested that combining DC Tron with methiocarb may have some potential in repelling and reducing the damage done by lorikeets on rambutans. This study indicates combining the specific chemical cues of DC Tron with methiocarb will greatly enhance the effectiveness of methiocarb.
ANIMAL HEALTH DIVISION

The Animal Health Division is broadly responsible for the health of commercial animals and birds in the Northern Territory and plays a role also in the health of domestic companion animals and native animals and in protecting the human community from animal transmitted diseases (zoonoses) or from diseases and chemical contaminants in animal products. This role entails the investigation of disease reports and proactive surveying to detect the presence of pathogens, plant and other toxins and deficiency states. In particular such surveying focuses on disease conditions not currently present in the Territory or Australia (exotic diseases) which present a serious threat to one or other of our animal industries.

Part of the Division's role lies in regulatory activities to control or eradicate animal diseases by controlling movement, requiring testing or removing infected animals or birds. Its officers also examine and certify livestock leaving the Territory to ensure that they meet the health requirements of the importing country.

The main activity in recent years and still the Division's largest project is the Brucellosis and Tuberculosis Eradication Campaign (BTEC). There has been no field or laboratory evidence of brucellosis in the Northern Territory since 1989 but there are still isolated appearances of tuberculosis.

GENERAL

+++ Tuberculosis Eradication

Project Period : Ongoing until 1997
Project Officer : B. Radunz
Project Location: NT

Objective:
It is planned that, by 1997, the Territory will be free of TB although a further eight years will have to pass, without any confirmed case of tuberculosis, in the Territory or elsewhere in the country, before Australia will be declared free.

Background:
The Tuberculosis Impending Free declaration in November 1992 was a culmination of years of work by many pastoralists and Departmental staff and the expenditure of $175 million.

BTEC is still the major program conducted by the Department. In 1993-94, 40 staff were involved with 28 salaries paid by the BTEC Trust Fund with a total expenditure of $9.9 million.

Activity:
Breakdowns
At the end of 1993 90% of the cattle and buffalo were TB free (Monitored Negative, Tested Negative or Confirmed Free 2).

There were seven breakdowns in the Impending Free area of the Territory in 1993-94. Five herds had a TB case found at slaughter of old cows and two herds had a TB case found by testing. Only one herd had more than one case of TB, two animals being found with TB.

Destocking
During 1993 about 19995 cattle were destocked to abattoir from 8 properties. TB was found in cattle from 3 properties with 8 infected animals found.

Bush destocking activity in all Category 3 areas was completed by the end of 1992. The 'Judas cow' radio tracking technique in bush areas is proving to be a valuable tool in locating residual animals. New collars have been introduced throughout the Darwin and Katherine region and have also been put in place in some Gulf areas in the Tennant Creek region. The goal to achieve the completion of bush destocking in all category 2 areas by the end of 1994 is on target.
Granuloma Submission Program (GSP)
The monitoring system includes a granuloma submission program which is working satisfactorily. A pleasing aspect of the granuloma submission program is that the majority of lesions which are detected through abattoir monitoring are not tuberculosis. This increases confidence that meat inspectors are submitting granulomas to assist the early detection of TB breakdowns.

During 1993 there were 52273 cattle and buffalo slaughtered at NT abattoirs. There were 91 granulomas detected with 14 confirmed to be TB.

### TB Testing 1993

<table>
<thead>
<tr>
<th></th>
<th>Number Tested</th>
<th>No. of Reactors</th>
<th>No with TB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle</td>
<td>359 377</td>
<td>357</td>
<td>2</td>
</tr>
<tr>
<td>Buffalo</td>
<td>2 102</td>
<td>30</td>
<td>6</td>
</tr>
</tbody>
</table>

Note: Buffalo testing was primarily in one infected herd having 6 animals with TB.

**Overall Progress**
The TB eradication program is proceeding well with eradication testing and bush destocking progressing to plan.

A small number of TB breakdowns will occur in decreasing numbers over the next few years. The risk of further breakdowns will be diminished when all breeders exposed to TB in the late 1980's have been slaughtered at abattoirs by age culling.

#### Market Access - Certification

- **Project Period:** 1946 ongoing
- **Project Officers:** D Napier and Regional Staff
- **Project Location:** NT

**Background:**
Certification, inspection and treatments of animals and certification of animals products are required to facilitate the marketing of Northern Territory stock. This is required for export, interstate and intrastate markets. Inspection and testing is for animal welfare aspects such as sickness, injury, pregnancy and general suitability to travel, for infectious conditions and for the presence of specific plant seeds, animal diseases or chemical residues prohibited by the importing state or country.

Despite decreased regulation within Australia there is a demand by buyers that animals and animals products are free of disease and residues. It is expected that there will be an increased need to justify disease freedom both on a country, region and property basis.

**Objective:**
- Provide property and animal certification for export and interstate movements.
- Assist the industry to satisfy export protocols by conducting required treatments if private veterinary practitioners are not available.
- Provide inspection and certification as agents for AQIS on a cost recovery basis.
- Facilitate interstate movements from the Tick Infected and Tick Protected areas by providing a service to inspect and/or treat cattle and horses for cattle ticks and for weeds.

**Method:**
Property certifications are provided to AQIS regarding the disease status of properties and animals to satisfy export protocols.

An associated project, to improve the reporting and retrieval of passive monitoring for this purpose, is the Animal Health Information System. Planned active surveillance complements passive monitoring.
Treatment of animals to be exported are required to satisfy some export protocols. The treatment may be done on the property of origin, export depots or at the Export Trucking yards by private veterinarians or by Departmental staff. Departmental staff provide a service, if available, if private veterinarians can not provide the service. There is an increasing trend for treatments to be done at the Export Trucking yards by private veterinarians. There is also a trend to prepare animals for a short period in a feedlot prior to embarkation to prepare animals for the ship voyage and the feedlot at the destination.

Inspection and certification of mobs for export is provided as agents for AQIS on the property of origin, export depots or at the Export Trucking yards on a cost recovery basis. There is a trend for this task to be done at the Export Trucking yard by AQIS staff. It is now only a major task when Departmental officers relieve AQIS officers during periods of leave.

Stock from the tick infected area require a clean treatment (clean inspection and treatment) to pass into or through the NT Tick Free area or into the Tick Free Areas of other States. Treatment is by plunge dipping or spraying for led and tractable horses and show cattle.

Progress Report:
Detailed statistics of activities will be available from 1994/95.

The following statistics are compiled from a waybill database. It is almost complete for the Tennant Creek region, with some data from the Alice Springs region and no data for the Katherine and Darwin regions. A copy of each waybill is required by law to be sent to the regional DPIF office. However, non-compliance is not prosecuted.

The purpose of the waybill database is to gather turnoff statistics for Departmental and Government use so that industry value, etc can be estimated and services to the industry eg. road building priorities can be determined.

As the database is incomplete, except for the Tennant Creek region, the statistics section of the Economics Branch obtain stock movement data from the departments of agriculture in Kununurra and Mt Isa to obtain interstate turnoff statistics. This does not provide by property statistics. Abattoir turnoff and export statistics do provide turnoff by property data.

The requirement for a South Australian health certificate for cattle ceased after 10/09/93. Since then, there has been poor record of the number of Alice Springs District cattle trucked to South Australian destinations due to poor compliance with return of waybills.

Cattle - Alice Springs Region
A total of 57,296 cattle were inspected through the Bohning Cattle Yards, Alice Springs in 1993-94.
A total of 1,395 horses were inspected through the Bohning Cattle Yards, in 1993-94 mainly for slaughter at Peterborough abattoir.
Export of Alice Springs district cattle to South East Asian markets was initiated in March 1994 with 2,722 cattle exported due to low supply in the Top End in the wet season. The cattle were not suited to the humid conditions in south east Asia.
A total of 32 camels and 103 buffalo in transit were also inspected at Bohning Cattle Sale Yards.

Nine cats and dogs were certified for overseas export.

Cattle - Darwin and Katherine regions
Turnoff from the Darwin and Katherine regions was mainly to abattoir or live export. See abattoirs report below. Total export through Darwin in 1993-94 was 153,771 head of which 95,098 originated in the Territory but not all from the Darwin Katherine region.

Cattle - Tennant Creek Region
7,642 cattle were clean dipped at the Elliott Clearing Dip in 1993.
Mobs inspected for cattle tick 376
Cattle inspected for cattle tick 137,682
Cattle dipped for cattle tick 4,299

Summary of activity in 1993/94

<table>
<thead>
<tr>
<th>Activity</th>
<th>No. of Consignments</th>
<th>Cattle Nos.</th>
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</thead>
<tbody>
<tr>
<td>Dipping</td>
<td>30</td>
<td>6,930</td>
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<tr>
<td>Scratches</td>
<td>160</td>
<td>77,307</td>
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<tr>
<td>Faxes</td>
<td>60</td>
<td>30,768</td>
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<tr>
<td>Live Export Cert.</td>
<td>49</td>
<td>16,719</td>
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<tr>
<td>No cer! required</td>
<td>106</td>
<td>23,940</td>
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<tr>
<td>TOTALS</td>
<td>405</td>
<td>155,664</td>
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</tbody>
</table>

*** Animal Welfare

Project Period: Ongoing
Project Officers: A Bryce, O Williams and regional staff
Project Location: NT

Objective:
Provide policy advice to government on animal welfare issues and participate in the development and implementation of national standards.

Progress:
No progress was made towards an upgrade to the NT Prevention of Cruelty to Animals Act.

The Code of Practice for Management of Buffalo, developed by the Northern Territory, was published as the national standard.

Advice was provided on various animal welfare issues including walking camels in poor/diseased condition, shooting of camels, research techniques for feral cats, tranquiliser gun use for capture of stray dogs in the Alice Springs township area, travelling horses and agisted horses in poor condition, travelling cattle in poor condition and yarded cattle with septic horn wounds.

A set of guidelines for the management of animal welfare issues resulting from injury, infection or tumour at the Bohning Cattle Sale Yards was developed.

Letters on cancer eye in cattle were posted to cattle producers and a series of five articles was published in the Alice Springs Rural Review.

O. Williams represented the Northern Territory on the National Consultative Committee on Animal Welfare (NCCAW), which advises the Commonwealth Minister for Primary Industry and Energy. NT provided the Chair of a national review group on the welfare of layer hens. NT provides the chair for the Sub-Committee on Animal Welfare with an NT representative as well.
Abattoirs

Project Period: 1975 ongoing
Project Officers: J Purdie and regional staff
Project Location: NT

Three export abattoirs were licensed, one did not operate during this period. The Broome abattoir in Western Australia closed during the year leaving only Katherine and Meneling still operating in competition with live export. Slaughterings were:

- 45,984 cattle
- 4,720 buffalo
- 469 horses

Two domestic abattoirs were licensed. Slaughterings were:

- 6,944 cattle
- 301 buffalo
- 6,441 pigs
- 283 camels
- 10 sheep
- 48 goats
- 1 deer

Five slaughterhouses were licensed, two did not operate. Slaughterings were:

- 251 cattle
- 45 buffalo

Three poultry abattoirs were licensed, one did not operate. Slaughterings were:

- 883,917 poultry

Total Slaughterings:

- 53,179 cattle
- 5,066 buffalo
- 6,441 pigs
- 283 camels
- 48 goats
- 10 sheep
- 1 deer
- 883,917 poultry

Pet Meat

15 Licenses to Slaughter
4 Licenses to Process
2 Licences to Store

Statistics for July - December 1993:

- 1,113 horses
- 508 donkeys
- 104 buffalo
- 42 cattle

Statistics for January - June 1994 are not available.

Kangaroo meat from Queensland is being regularly imported.
Chemical Residues in Animal Products

Project Period: 1990 ongoing
Project Officers: B Radunz, D Russell, K Lunn, R Baker and B Tye
Project Location: NT

NT animal industries do not have a chemical residue problem. There are no properties under quarantine. However, there are ongoing programs to monitor the situation.

Objectives:
Present chemical residue free animal product to the consumer and to protect and maintain the NT meat and milk markets.

Provide an advisory service on chemical residue issues to industry, government and the public.

Represent NT on relevant national committees.

Background:
This program has five components:
. The National Residue Survey (NRS) which is a random sample survey to monitor residues in Australia’s agricultural food commodities.

. The beef organochlorines, organophosphates and synthetic pyrethroids residues program. Following the detection of unacceptable levels of organochlorines (OCs) in beef in the US in 1987, an expanded program for OCs called the organochlorine Extended Residue Program (ERP) started. The program ceased on 30 June 1993.

. The Hormonal Growth Promotant (HGP) Vendor Declaration program. In 1989 Australia developed a Vendor Declaration system for HGPs to comply with European Union (EU) meat import requirements. The seller declared that the animals have not been treated with HGPs (A declaration) or that the stock has been treated (B declaration). Waybills were printed to facilitate the HGP declaration and advice on the HGP declaration was provided. This program was an industry initiated program with DPIF providing legislative support.

An organochlorine survey in pigs monitors slaughter pigs to detect the presence of organochlorins. This is a local program assisted by AQIS inspectors who collect samples at abattoirs to be analysed at the Berrimah Laboratory. Approximately 7500 pigs are killed for domestic consumption annually in Territory, with at least 6000 from one commercial piggery.

The National Antibacterial Residues Program (NARM) is a national program to monitor antibiotic and antibacterial contaminants.

Activity:
National Residue Survey (NAS)
During 1993 samples were collected from 8 cattle compared to 123 cattle and 143 buffalo in 1992. The samples from cattle are the NT component of an annual random sample required from Australian cattle to maintain access to the United States and European Union markets. There were no residues detected.

Sixty eight samples were taken from the poultry meat survey. Metal residues were detected but none were violations. Twenty nine samples were taken from poultry eggs with no residues detected.

No samples were taken from buffalo in 1993. From 1 July 1993, the Commonwealth Government ordered that the NRS must be totally funded by the industry. Due to the low number of buffalo slaughtered, the levy was $5 per head for each buffalo slaughtered. As the European Union (EU) insists of an annual sample of 300 and continued access to the EU is essential, the abattoir industry agreed to the payment of this levy for 1994 so that buffalo product could be exported to the EU.
Beef Organochlorines, Organophosphates and Synthetic Pyrethroids

Following an organochlorine crisis involving an opportunity feedlot in Queensland in late 1993, a Targeted Residue Testing (TRT) program was started to sample high risk properties. Only 2 tailtag areas in the NT were identified with 1 sample taken with no residues found.

The main issue during the year was the interval between the last treatment with cattle tick and buffalo fly synthetic pyrethroids and some organophosphates and slaughter to satisfy the MRL in both domestic and export markets. There is no minimum interval for amidin tickicides but is 3 to 8 weeks for synthetic pyrethroids.

Hormonal Growth Promotants (HGP) Vendor Declaration

In late 1992, EU reviewers advised industry and governments that the current vendor declaration system for HGP did not satisfy EU requirements.

Industry (exporters, cattle council and livestock agents) decided that it was important to maintain the $80 million market to the EU.

Over a 6 month period a revised enhanced national program was developed which satisfied EU reviewers subject to on-going review. Legislation has been activated by all state governments with the Control of Hormonal Growth Promotants (Stock Act) becoming law from April 1993.

The enhanced system consists of:

- registration, audit and reporting by sellers
- permanent identification of treated stock with random audit and record keeping of treated stock sold (Purchaser Declaration Forms at the retailer)
- stock to be eligible for EU must be accompanied by a Vendor Declaration for Untreated Stock and all stock must also be tailtagged with the same tailtag as the declaration. Untreated stock sold through saleyards must be identified with pink paint on the tail butt or with pink tailtags

From 1 April 1994, cattle producers could use a pink ear tag or tailtag instead of a Vendor Declaration Form.

There were 4 registered retailers in 1993 and 3 in 1994 and 19,000 doses of HGP were sold by registered retailers in 1993/94. The majority is used to treat cattle just prior to export to Asia.

AQIS prosecuted one stock agent and two Alice Springs District station managers for false Hormonal Growth Promotants (HGP) declarations. Summons for another station manager is pending.

An Agnote was sent to all producers in April 1994 and a letter about the new HGP requirements in South Australia from 01/07/94, was posted to all Alice Springs cattle producers and printed in the Alice Springs Rural Review in May 1994.

National Antibacterial Residues Minimisation Program (NARM)

Urine samples are collected and screened on-plant at the abattoir by AQIS officers and test positives are sent to AGAL for laboratory confirmation. Samples are collected from pigs, calves and cull bovine and buffalo and especially culled dairy cows. The program ceased in late 1993 due to lack of funding.

Organochlorine Survey in Pigs

There has been a marked decline in residues detected since 1988 and 1989 due to relocation of piggeries from contaminated sites and some producers leaving the industry. Dieldrin and oxychlordane are the OCs usually found. They have been used in the past for termite and fly control and remain in the environment. The following table lists the findings of OC residues in pigs since 1987.
OC Residue Detections Pig Fat

<table>
<thead>
<tr>
<th>Year</th>
<th>No. of Samples</th>
<th>&gt; MRL</th>
<th>.5 TO 1 MRL</th>
<th>&lt; .5 MRL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987</td>
<td>89</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>1988</td>
<td>135</td>
<td>12</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>1989</td>
<td>100</td>
<td>7</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>1990</td>
<td>84</td>
<td>1</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>1991</td>
<td>30</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>1992</td>
<td>37</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>1993</td>
<td>36</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

MRL = Maximum Residue Limit

Soil contamination was found on the two properties. Property Management Plans were developed with the two producers to prevent residues in food products.

The continuation of the program was reviewed at the end of 1993 and will continue to identify organochlorine contaminated pig premises.

**Cattle Tick and Tick Fever Control**

**Project Period:** 1966 ongoing
**Project Officers:** B Radunz, D Russell, K Lunn and F Dayes
**Project Location:** NT

**Objectives:**
- Prevent the spread of cattle tick from NT Cattle Tick Restricted Area to tick-free areas within the NT and interstate.
- Facilitate livestock movements.
- Prevent entry of cattle tick from interstate, particularly acaricide resistant strains from Queensland.
- Provide chemicals and equipment for DPIF mobile treatment facilities.

**Background:**
There is continual review of stock movement controls and area declarations in consultation with Queensland Department of Primary Industry (QDPI), Western Australian Department of Agriculture, industry associations and chemical companies. Mobile spray plants and chemicals are provided for spraying horses.

**Activity:**
The spread of cattle tick was prevented while movement to Queensland, WA and SA was facilitated.

In February 1994, meat processors placed a 21 day embargo on dipped cattle prior to slaughter. This was to prevent the risk of further residue violations in the USA market despite Australian MRLs being satisfactory. A 42 day withholding period was placed on Bayticol Pour-on®. Extension activity was an important response from Tennant Creek staff. Elliott and Walhallow approved dips are now being charged with Amitraz® which has been shown to comply with USA requirements with no withholding period.
Monitoring for Chemically Resistant Strains of Cattle Tick

Project Period: 1969 ongoing  
Project Officer: B Radunz and Regional Staff  
Project Location: NT cattle tick area

Objective:  
Control cattle tick with recommended, registered acaricides.  
Locate chemically resistant strains of cattle tick on NT properties and prevent their spread.  
Advise industry on correct chemical use.  
Advise industry on chemical control of resistant cattle tick strains and liaise with QDPI on this matter.

Method:  
Fully engorged female cattle ticks are collected in the field and sent to CSIRO Division of Tropical Animal Production, Indooroopilly, for processing and larval packet testing against a number of tickicides. Collector and station owner/manager are given the results and appropriately advised. The program targets properties which report poor tick kill and properties on which Clout® and/or Bayticol® pour-on is used.

Results:  
A minor level of organophosphate (OP) resistance has been found in NT but there is no resistance to amidines or synthetic pyrethroids.

Monitoring Cattle Dip Strength

Project Period: 1969 ongoing  
Project Officer: B Radunz and Regional Staff  
Project Location: NT cattle tick area

Objectives:  
Maintain an NT Dip Register to assist in the monitoring of strength and to ensure government and private dipping facilities are run at correct strength for stock movement.  
Provide an advisory service on correct dip chemical usage, plunge dip management and choice of acaricide.  
Provide a dip analysis service.

Method:  
Dip sample bottles, dip sampling sticks and an analysis service are provided for industry and government. Dip samples are collected by station staff, veterinary officers and stock inspectors. Samples are sent to BARC Chemistry Section. Collector, Station owner/manager and Program Manager are notified and appropriate advice is given.

Activity:  
An NT Dip Register completed in 1992 was maintained. There were 122 plunge dips identified on 78 properties. Thirty of these dips were in the Protected Area which has not been tick infested for a number of years. Two clearing dips are now charged with amitraz.

There is low use of acaricides except for movement treatment, due to the increasing proportion of brahman content in the breeding herd in the tick endemic areas. A total of 42 dip samples from 20 properties were collected. Of these 10 samples were at correct strength, 8 samples over-strength and 24 samples under strength.
Tick Fever Serological Survey

Project Period: 1992-1995
Project Officers: B Radunz, D Pinch and regional staff
Project Location: Marginal and Infected Tick Areas

Objective:
To assess the immune status of young cattle in the marginal and infected tick areas, so that appropriate advice on preventive vaccination can be provided.

Method:
Fifty blood samples from each of two age groups (weaners and 1 to 4 year olds) were collected from selected properties from the northern Barkly Tablelands and northwards.

The blood samples were tested for antibody levels to two tick fever organisms - *Anaplasma marginale* and *Babesia bovis*.

Results:
Samples were received from 10 stations in 1993. Sampling and laboratory testing is occurring for the 11 stations identified for 1994.

Survey results from the northern Barkly Tableland show low to nil levels of antibody to either tick fever organism.

Survey results from the southern Katherine region and Gulf properties range from low/nil to around 50% depending on location, breed composition and tick populations. A paper will be prepared for publication and extension material produced at the completion of the survey in late 1994.

General Disease Investigation

Project Period: 1946 ongoing
Project Officers: Regional and Veterinary Laboratory officers
Project Location: NT

Background:
A reactive service is provided to industry to investigate disease and provide disease control advice. Loss of production is reduced by cost effective advice on disease prevention and passive monitoring provided by this reactive service provides data to maintain market access for animals and animal products.

Objectives:
Investigate unusual disease events in order to confirm or exclude the presence of exotic disease.

Investigate significant disease events causing loss of production and/or mortality.

Provide advice on disease control.

Method:
Disease events such as mortality, sickness and illthrift are reported by producers. It may be possible to offer a diagnosis or control method immediately. If not, a property visit is undertaken to investigate the history, conduct a clinical examination of affected stock, collect samples, conduct autopsies and collect samples for laboratory examination.

Samples are examined at the Animal Health Laboratory, BARC, with some samples being referred to other laboratories. Following assessment of the field investigation and laboratory findings, the producer is advised of
the diagnosis, if any can be made, and control measures are discussed.

Practical and cost effective disease control measures will be adopted by producers. The aim is to prevent further occurrence of the disease or identify methods to minimise the loss from the disease.

Activity - Darwin Region:

**Project Officers:** K Small, D Pinch and regional staff

**Investigation of Suspect Exotic Disease**

An unusual disease event on a poultry farm near Darwin with layers showing increased mortality, loss of production and inappetence was investigated. Exotic disease was eliminated as a cause and an infectious agent was not identified. A combination of nutrition and management were considered to be the cause of the problem.

A dog from Bathurst Island with nervous symptoms consistent with rabies was autopsied and brain samples collected. Rabies diagnosis was excluded. Samples were submitted to AAHL at Geelong where there are specialised advanced techniques for the diagnosis of exotic disease.

**Endemic Disease**

Investigations undertaken January-June 1994 by Region

<table>
<thead>
<tr>
<th></th>
<th>Darwin</th>
<th>Katherine</th>
<th>Tennant Creek</th>
<th>Alice Springs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investigations done</td>
<td>914</td>
<td>161</td>
<td>57</td>
<td>75</td>
</tr>
<tr>
<td>Cattle</td>
<td>179</td>
<td>110</td>
<td>52</td>
<td>48</td>
</tr>
<tr>
<td>Horses</td>
<td>52</td>
<td>6</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Crocodiles</td>
<td>39</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Camel</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Other</td>
<td>644</td>
<td>38</td>
<td>2</td>
<td>15</td>
</tr>
</tbody>
</table>

This data includes all field investigations and submissions to the veterinary laboratory.

**Activity - Katherine Region**

**Project Officers:** K de Witte and regional staff.

**Fluorosis**

The confirmation of severe dental damage in breeder cattle due to fluorosis (excess fluorine) in mineral supplement. The affected cattle suffered ill thrift and a poor prognosis for survival in the long term as breeders. Fertiliser sources of phosphorus are no longer recommended or are commercially available.

**Coccidiosis**

Outbreaks of coccidiosis or black scours were confirmed in several herds of weaner beef cattle. Improved nutrition and medicated feed are able to control the infection.
Botulism
Dramatic losses of 30% of a breeder cow herd due to type D botulism were confirmed by various laboratory tests. The cattle were vaccinated with type C botulism vaccine. The regional recommendation is vaccination with bivalent botulism vaccine.

Plant Toxicity
Losses of weaner cattle on one property were confirmed to be due to the bush cucumber or paddy melon (Cucumis melo). Hungry weaners being tailed out of a cattle yard in a holding paddock with a dense crop of the paddy melons.

Marek's Disease
Marek's disease was confirmed in vaccinated poultry. A new strain of virus was suspected but not confirmed.

Stringhalt
Stringhalt in cattle is a condition of emerging importance that results in a hind leg gait problem that interferes with the animals ability to walk. A number of diagnoses were made around the region differentiating lameness and gait abnormalities due to other causes. Not much is known about the condition and there is debate about whether environmental or genetic differences are more important for the expression of the problem. A small herd of affected cattle is being kept at KRS for demonstration and study purposes.

Sentinel Poultry Flock
A sentinel flock of poultry has been maintained at various locations in Katherine and bled monthly for Newcastle disease and Avian influenza of poultry and the human arbovirus infections of Australian Encephalitis and Kunjin virus.

Activity - Tennant Creek Region

Project Officers: A Brown and regional staff

Supplementation Trial
The results of the evaluation of reproductive parameters from the MacArthur River Wet Season Supplementation Trial have been finally documented as a Technical Bulletin. However, approval from the station owner is still awaited before publication proceeds.

Birdsville Disease
Birdsville disease (Indigophora linnae poisoning) was identified as the cause of losses of horses in the Renner Springs area.

Ephemeral Fever
Outbreaks of bovine ephemeral fever were observed on about 20 properties in the Barkly Tablelands, Gulf and Daly Waters areas. Mortality was highest in 2 year old heifers and steers (up to 4%).

Zamia Palm
Properties in the endemic zamia palm area east of Borroloola had cattle losses.

Botulism
A heavy challenge of botulism on one property in the northern Barkly Tablelands required two effective vaccinations to prevent mortality.

Pompes Disease
Information was researched and extended on pompes disease.

Sentinel Herd
A sentinel herd has been regularly bled for arbovirus in the Elliott area. This region is the only supplier of samples taken from commercial sentinel herds for the NT contribution to the NAMPS program.
Ultrasound
A Doppler ultrasound pregnancy testing machine was tried and evaluated for a property in the Barkly Tablelands and a report compiled and sent to the owners.

Pregnancy Testing
Pregnancy testing workshops have been held on a number of stations in order to train head stockmen with these skills. Pregnancy testing has also been provided as a service on one station in the Barkly Tablelands and to gather further reproductive information.

Activity - Alice Springs Region

Project Officers: J Coventry and regional staff

Bovine Ephemeral Fever
The AZRI Sentinel Cattle herd was sampled at monthly intervals and routinely replaced with weaner cattle in November 1993. After an initial acclimatisation and training period the new herd continued the consecutive sampling (10 times) in 1993-94. Titres to bovine ephemeral fever (BEF) were noted in 50% (11/20) of the AZRI Sentinel Herd in May 1994.

Leptospirosis Survey
A survey of the incidence of leptospirosis linked occurrence to age, pregnancy status, rainfall and temperature.

Weaner Pneumonia
Vibrio cholerae was isolated from cases of weaner pneumonia, only the second time this pathogen has been identified in the Territory.

Sodium Fluoroacetate (1080) Poisoning
An outbreak which killed 15 dogs and affected a further 30 was believed to have been associated with dingo baiting.

Parakeelia Poisoning
A case of mortality in fat trucked cattle due to oxallic acid induced hypocalcaemia was traced to the ingestion of parakeelia (Calandrivina sp.). This member of the Portulaca Family is widely grazed in Central Australia, normally without ill effect.

Plant Poisoning in Hay
Hay containing the grass Setaria vertioliata caused one mortality and ten cases of illness in camels being prepared for the Alice Springs Camel Cup.

Ketosis
An episode of ketosis in adjustment cattle was probably caused by stress and sudden change of feed.

Solanum Poisoning in Horses
Wild tomato (Solanum sp.) caused poisoning in plant horses.

Solanum Poisoning in Poultry
An episode of poisoning of domestic poultry with Solanum nigrum was investigated.

Fowl Pox
An outbreak of fowl pox in several domestic flocks was believed to have been introduced by native birds.

Psitticosis
An outbreak of psitticosis in wild pink and grey galahs was responsible for heavy mortality in the vicinity of Alice Spings. The outbreak presented a zoonotic risk.

Ringworm in a Kangaroo
A case of ringworm in a pet kangaroo sparked a zoonotic episode in which an entire family and the neighbours
also contracted the condition.

**Zoonosis from a Snake**
A case of *Klossella* sp. infection in a pet carpet snake presented a potential zoonotic risk.

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**Botulism Survey - Darwin Region**

**Project Period**: 1993 ongoing  
**Project Officers**: K Small, D Pinch and regional staff  
**Project Location**: Darwin Region

**Objective**:  
Gather information on the significance of botulism in the Darwin region.

**Background**:  
Despite botulism being a common disease in unvaccinated cattle in other parts of the Northern Territory, outbreaks of botulism have only rarely been reported in the Darwin region. The disease has only been confirmed on a few occasions. There is limited use of vaccination to protect against the disease.

The lack of specific changes detectable at necropsy in suspect cases makes diagnosis of the disease difficult. Detection of toxin by the mouse inoculation test has a very low sensitivity. Surveys to detect *Clostridium botulinum* in faecal samples may have little correlation with the presence of clinical disease.

**Method**:  
Recently an enzyme linked immunosorbent assay (ELISA) for antibody to botulinum toxins has become available for use at the Department of Agriculture Western Australia (Jubb et al 1993).

Properties with no vaccination history were selected for the survey. Serum was collected from a sample of cows on 4 properties and tested for antibodies to botulism type C and type D toxin.

**Results**

<table>
<thead>
<tr>
<th>Property</th>
<th>No of Samples</th>
<th>Type &quot;C&quot; Toxin antibody</th>
<th>Type &quot;D&quot; Toxin antibody</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>High +ve</td>
<td>Low +ve</td>
<td>Neg</td>
</tr>
<tr>
<td>1</td>
<td>40</td>
<td>2</td>
<td>3</td>
<td>35</td>
</tr>
<tr>
<td>2</td>
<td>45</td>
<td>3</td>
<td>12</td>
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<td>4</td>
<td>46</td>
<td>3</td>
<td>43</td>
<td>4</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>183</strong></td>
<td><strong>17</strong></td>
<td><strong>15</strong></td>
<td><strong>151</strong></td>
</tr>
</tbody>
</table>

In the survey sample 15% of cows had received natural exposure to botulism toxins at some time in their life. Each of the herds had no history of disease due to botulism. Each herd had a cow mortality rate of less than 2%. All cows received mineral supplementation.

**Discussion**:  
Although no outbreaks of deaths due to botulism have occurred in these herds, it is possible that there are occasional deaths due to botulism. The break even mortality for vaccination with bivalent type C and type D vaccine is 0.5% annual mortality.
Weaner Illthrift

Project Period: 1993-94
Project Officers: K Small, D Pinch and regional staff
Project Location: Darwin region

Objective:
Investigate loss of production in weaners.

Background:
Diarrhoea and ill thrift are common findings in weaners. Calves are weaned at low body weights to avoid severe lactation stress on cows during the dry season. Various supplementary feeding regimes are recommended for early weaned calves but supplementary feeding often involves crowding of stock at feeding points and faecal contamination of feed.

Method:
Faecal oocyst numbers were counted to assess the significance of coccidiosis and faecal egg counts were done to assess helminth burdens. Responses to helminth and coccidia control measures were recorded.

Results:
Weaners fed for short periods of up to 2 weeks in holding yards showed no signs of diarrhoea. Feeding weaners for up to 4 weeks in holding yards resulted in a build up of intestinal nematodes and coccidia resulting in diarrhoea and ill thrift even when feeding a high quality ration.

Diarrhoea was found in calf groups with average faecal oocyst counts over 500 and individual counts in excess of 1000. Eimeria zuerni and E. auburnensis predominated.

Treatment with pour on Ivermectin® at weaning resulted in negligible faecal egg counts for up to 57 days but did not prevent the development of diarrhoea. Feeding 20 mg of Monesin® per calf per day in a weaner meal prevented the development of diarrhoea and kept the average faecal oocyst count at about 50 oocysts per gram of faeces. At least 500 g of a palatable calf or weaner commercial meal needs to be fed to calves daily to accompany the Monesin®.

Exotic Disease Preparedness

Project Period: 1992 TO 1994
Project Officers: J Millan and regional and head office staff
Project Location: NT

Objective:
To participate in contingency planning and training for exotic disease preparedness. To ensure that DPIF staff, relevant organisations and pastoralists have a continuing high level of awareness in relation to the threat of exotic diseases.

Activity:
Mt. Isa Exercise
An exotic animal disease exercise was held on 10 - 12 August 1993 in Mt Isa. The activity aimed to identify and address issues and problems specifically related to the control of an exotic disease outbreak involving more than one State. It was organised and run by the EXANDIS (Exotic Animal Disease Consultative Council) funded officers in the Northern Territory and Queensland.

There were 57 participants (18 from the NT) with representatives from DPIF, Qld DPI, WA Department of Agriculture, NSW Agriculture, Victorian Department of Agriculture, Emergency Management Australia, NT Emergency Services, State Emergency Service (Qld), NT Police, Qld Police, Royal Australian Army, St John Ambulance (NT), Livestock & Meat Authority of Qld, United Graziers Association, North Australian Pastoral Co, Qld & NT Pastoral Co, Stanbroke Pastoral Co, Dept of Lands (Qld), Dept of Environment & Heritage (Qld),
The activity was very successful and is to be followed by a large operational exercise in August 1994, based in Goondiwindi, involving Qld, NT and NSW.

Public Awareness
Exotic disease displays were exhibited at the annual shows and KRS and BARC Open Days in order to make producers and the public aware of the risk of exotic diseases and their appearance.

Exotic Disease Reviews
Two reviews were completed under Wildlife Exotic Disease Preparedness Program (WEDPP) funding - Review of Wild Herbivores and Exotic Disease, and Review of Exotic Disease and Feral Pigs.

Honey Bee Industry Development

<table>
<thead>
<tr>
<th>Project Period</th>
<th>1993 and ongoing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Officers</td>
<td>K de Witte, J Kearins and regional staff</td>
</tr>
<tr>
<td>Project Location</td>
<td>Throughout the Territory</td>
</tr>
</tbody>
</table>

Objective:
Provide technical advisory, disease investigation and diagnostic laboratory support for the bee industry to maintain the disease free status for Northern Territory bee products.

Background:
The apiary industry in the NT continued to grow in the 1993-94 period and maintained the NT position as an exporter of honey. The current program direction has been to provide industry advice on disease prevention, monitor for the important bee diseases and to raise the awareness of control of bee diseases staff and the public to protect the Territory disease free status and ability to trade interstate.

Activity:
Produced media releases and extension articles for regional newsletters. An apiary industry database was developed. An amendment to the Stock Diseases Act provided clear power to control bee equipment entering the Northern Territory in order to protect bee health.

The following Agnotes on bee diseases were completed; K11 Chalkbrood Disease of Honey Bees, K13 American Foul Brood of Honey Bees, K14 European Foul Brood of Honey Bees.

Most liaison is with a major apiarist, located near Katherine, who is concerned about market access for his product. Certification is provided to assist the sale of honey. The staff and public awareness campaign continues as extension material is upgraded and industry contacts are renewed. Some staff training will be necessary.

A survey of locally produced honey has confirmed the absence of the major diseases of bees.

Herd Health and Production Programs

<table>
<thead>
<tr>
<th>Project Period</th>
<th>1991-1997</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Officers</td>
<td>O J Williams, J Coventry, and B Tye</td>
</tr>
<tr>
<td>Project Location</td>
<td>Mt Riddock, via Alice Springs</td>
</tr>
</tbody>
</table>

Objective:
Develop a pilot cattle herd health and production program on a property in the Alice Springs area.

Background
The Mt Riddock Pilot Herd Health Project involves study of a poll hereford beef cattle herd, on a north-east...
Alice Springs District Property. The study is half way through the planned five year data collection phase. The assigned five year collection period provides an opportunity to record the effects of season variability and long term management objectives.

This project aims to address gaps in information on breeder herd health, structure and performance in the Alice Springs District. Data and samples are collected from specific groups of cattle during biannual musters and at 6 weekly field surveys. Samples are tested at the Animal Nutrition Laboratory at AZRI and the Animal Health Laboratory at BARC and analysis of data and test results provides an objective data base to:

- evaluate breeder herd health, structure and performance,
- identify performance constraints,
- establish techniques for potential further studies within the Alice Springs District,
- determine future Industry needs for research, disease prevention/control and advisory activity.

Progress in 1993-94
The Mt Riddock Pilot Herd Health Project has completed its second year of data collection. In the past 12 months, data and samples were collected from a further 2 cattle musters, 4 cattle surveys and 7 grass surveys.

Twelve indications of herd health, structure and performance problems /constraints were noted in 1992-93. Five of these were also evident in 1993-94:

- Titres to bovine viral diarrhoea.
- Titres to leptospirosis.
- Seasonal effects on testicular tone.
- Change in the cow herd age distribution.
- Estimation of calves conceived per breeder year.

Additional indications of herd health, structure and performance problems /constraints noted in 1993-94 were:

- Relationship between seasonal onset of frosts, growth of grass, quantity of available feed and faecal indicators of cattle nutritional status.
- Fluctuation of cattle nutrition faecal indicators, below critical levels.
- Differences in breeder cattle blood analyses at musters and surveys.
- Variable range of lactating cow versus dry cow condition scores, depending on the area of muster.
- Changing annual patterns of conception.
- Annual variation in the calculated calf percentage.
- 50% probability of cattle identified as poor breeders, being culled the following muster.
- Gross kidney changes in cows and steers at slaughter.
- Significant levels of intestinal parasites in weaners.

Chemical Restraint of Saltwater Crocodiles

**Project Period** : 1993-94
**Project Officers**: J McInerney and V Simelesa
**Project Location**: Darwin and Katherine regions

**Objective:**
To establish:
- a safe dose rate for an anaesthetic suitable for use in adult crocodiles;
- a cost effect safe dose rate for a muscle relaxant suitable for use in wild adult crocodiles.

**Background:**
There is no satisfactory injectable anaesthetic available for use in large crocodiles. The literature is confused on the subject.
Gallamine (Flaxidyl®) has been used for the chemical restraint of crocodiles for a number of years. The dose rate has been fine tuned and is well known. Some animals have died whilst under its influence which may have been due to other causes (overheating, stress). However, gallamine is an expensive drug. There are other similar preparations in the same class of drugs (muscle relaxants) that are considerably cheaper.
Method:
Large saltwater crocodiles captured and removed from Darwin Harbour as part of the Northern Territory problem crocodile program were used as experimental animals.

All the animals were caught in a trap. The length of the animal was estimated and the dose of the trial chemical calculated.

Some of the chemicals used have recognised antagonists. These were used where appropriate.

The drugs used were:
- etorphine (Immobilon ®) - narcotic
- diprenorphine (Revivon ®) - narcotic antagonist
- xylazine (Rompun ®) - sedative
- tilatamine/zolazepam (Zoletil ®) - anaesthetic
- 4-amino prydine (Xylex ®) - xylazine antagonist
- yohimbine (Reverzine ®) - xylazine antagonist
- alcuronium chloride (Alloferin ®) - curare type muscle relaxant
- suxamethonium (Scoline ®) - depolarising muscle relaxant

Results:
The following are the optimum dose rates found (in ml):

<table>
<thead>
<tr>
<th>Crocodile Length (ft)</th>
<th>8</th>
<th>10</th>
<th>12</th>
<th>14</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immobilon® (9.8 mg/ml) I/M</td>
<td>5</td>
<td>6</td>
<td></td>
<td></td>
<td>30 min some pupil dilation, very flaccid, some eye reflex. At 2 hr no eye reflex, pupil fully dilated.</td>
</tr>
<tr>
<td>Revivon® (6 mg/ml) I/V</td>
<td>5</td>
<td>6</td>
<td></td>
<td></td>
<td>20 min fully alert, possibly some excitement for 40 min</td>
</tr>
<tr>
<td>Rompun® (100 mg/ml)+ Zoletil® (100 mg/ml) I/M</td>
<td>1</td>
<td>1.5</td>
<td>2</td>
<td>4</td>
<td>30 min heavily sedated, some pupil dilation. 2 hr no change. 4 hr starting to recover. 18 hr fully alert.</td>
</tr>
<tr>
<td>Xylex® (24 mg/ml) + Reverzine® (10 mg/ml) I/V</td>
<td>3+3</td>
<td></td>
<td></td>
<td></td>
<td>30 min pain reflex, 1 hr fully alert.</td>
</tr>
<tr>
<td>Scoline® (50 mg/ml) I/M</td>
<td>1</td>
<td>3</td>
<td>5</td>
<td>9</td>
<td>25 min movement greatly diminished, recovery starts at 35 min fully recovered at 75 min.</td>
</tr>
<tr>
<td>Alloferin® (5 mg/ml) I/M</td>
<td></td>
<td></td>
<td></td>
<td>1.5</td>
<td>30 min fully relaxed, recovery starts 3 hr, fully recovered 12 hr.</td>
</tr>
</tbody>
</table>

Discussion
The Rompun®/Zoletil® ® mix appears to give good levels of anaesthesia for 3 hours. If required, it should be possible to administer more Zoletil® I/V to prolong the period of anaesthesia. The xylazine antagonists appear to work well.

Scoline worked well but suffered from the shortness of effect. It would be very useful drug if only a short period of restraint is required.

The saltwater crocodile seems to be especially sensitive to the effects of Alloferin®. It is a very effective drug
in inducing long acting muscle relaxation. However, unlike Scoline® where the period of apnoea (no breathing) is short (at most 10 mins) Alloferin® produces more profound apnoea which can be fatal. For this reason the dose rate of Alloferin® is more critical.

During the whole project only two crocodiles were lost, both to Alloferin®. Neostigmine would be an effective antagonist and intra tracheal tube and artificially ventilating the animal would prevent death.

It was noticed that when a crocodile is injected I/M the drug will take effect much more rapidly if the animal is encouraged to move. Some animals simply lay submerged on the bottom of the trap after injection. In these animals the absorption of the drug seems to take far longer. Possibly this is due to the low perfusion rate in resting crocodile muscle, resulting in slow absorption.

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**Liver Enzymes and Pathology in Runt Crocodiles**

**Project Period:** 1992 and ongoing

**Project Officers:** J McInerney and V Simelesa

**Project Location:** Darwin and Katherine regions

**Objective:** Examine some of the possible causes of failure of young crocodiles to thrive.

**Background:**
Some young crocodiles develop total or partial anorexia (cessation of eating) at the age of one to two months and either die over the next month or two, grow very slowly or stop growing entirely. Affected crocodiles fail to develop the rounded belly of fast growing young crocodiles and may become frankly emaciated. It is possible for anorexic crocodiles to be no bigger than hatchlings at two years of age.

This failure to thrive, leading to death, in hatching crocodiles is the most significant problem facing crocodile farmers in the Northern Territory. On some farms up to 30% of the animals in the shed can be affected. The vast majority of these animals die in their first year of life. Some do survive until they have to be moved from the hatching accommodation to make way for the following year's crop, generally these then succumb in the harsher environment of the growing pens.

The cause is unknown but it is possible to identify animals that will become runts after two months of age.

**Activity**

**Case History**
A large crocodile farm in the Northern Territory moved 50 one year old runt crocodiles from hatching pens to growing pens. At moving the average weight of the crocodiles was 105 gm whereas the average weight of normal crocodiles at one year is about 800 gm.

Blood samples were taken from 10 of these runts. At a similar time, blood was taken from 36 animals of the same age that had experienced normal growth in their first year.

During or soon after the bleeding procedure two of the runts died. These animals were submitted for autopsy. The post-mortems revealed little out of the ordinary. The animals were in poor condition with no body fat. The livers were pale and histology revealed a degree of fatty infiltration. This is a common finding in runts.

<table>
<thead>
<tr>
<th>Units</th>
<th>Runts mean</th>
<th>Normal mean and range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alanine A-Transferase U/L</td>
<td>39</td>
<td>30 (10 - 53)</td>
</tr>
<tr>
<td>Aspartate A-Transferase U/L</td>
<td>157</td>
<td>55 (24 - 86)</td>
</tr>
<tr>
<td>Alkaline Phosphatase U/L</td>
<td>75</td>
<td>56 (23 - 85)</td>
</tr>
</tbody>
</table>
Discussion
Except for aspartate A-transferase, which is a liver function indicator the values for the runts are within the range for the normal crocodiles and no conclusions have been drawn so far, other than that the runted animals may be suffering from a metabolic disorder induced by starvation. There are similar syndromes affecting constricting snakes. Studies will continue in 1995.

It has often been suggested by the stockmen on the farms that these animals are hungry and want to eat, but for some reason refuse the food offered. The hatchlings can sometimes be observed sitting on a pile of mince meat snapping at the flies that are attracted to it. It has also been observed that if tadpoles are released into the pens containing these hatchlings they chase and eat them.

In another farm the feed has been slightly changed to improve its palatability. In this season the overall mortality has reduced from 15% to less than 3%. The ones that are dying are the well grown crocodiles and generally they suffer sudden death from bacteraemia.

__Treatment of Runting in Saltwater Crocodiles__

**Project Period:** 1992 and ongoing

**Project Officers:** J McInerney and V Simelesa

**Project Location:** Darwin and Katherine regions

**Objective:**
Find a treatment that will induce runt crocodiles to resume growth.

**Background:**
Since the cause is not known treatments attempted were empirical. To be useful a treatment must have a significant effect, be cheap, readily available and easy to administer.

**Method:**
Four groups (three and control) of 13 runts were identified. All the animals were older than one year and between 100 and 150 gms. Weight gains were used to give a quick reading and early indication of a response.

**Treatments Used**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Dose</th>
<th>Route</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin B Complex</td>
<td>0.1 ml I/M</td>
<td>single injection</td>
<td></td>
</tr>
<tr>
<td>Metronidazole (Flagyl®)</td>
<td>0.1 ml orally</td>
<td>3 times a week</td>
<td></td>
</tr>
<tr>
<td>Norandrostenolone</td>
<td>0.1 ml I/M</td>
<td>single injection</td>
<td></td>
</tr>
<tr>
<td>(Laurabolin) 25 mg/ml</td>
<td></td>
<td>weekly injection</td>
<td></td>
</tr>
<tr>
<td>Human Growth Hormone</td>
<td>0.5 mg/gm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Results**

Vit B was the only treatment to show any response. However, the response was temporary for about 4 weeks.

Laurabolin injection and Flagyl® dosing had no effect. With Flagyl® there was a noticeable increase in aggression after the first week.

The human growth hormone appeared to have a negative effect.
**BERRIMAH VETERINARY LABORATORIES**

The Berrimah Veterinary Laboratories provide diagnostic laboratory support to animal health services, animal production research and fishing/aquaculture industries throughout the Northern Territory. Service is also provided to veterinarians in private practice, to other Territory and Federal departments, health authorities and educational institutes as necessary and appropriate.

There are three main sections, pathology (including anatomic and microscopic pathology, clinical pathology and parasitology), bacteriology and virology. Serologic testing is performed in all three sections, tests for export certification being shared between clinical pathology and virology sections.

A total of 2710 accessions were processed during the year, an increase of more than 20% over the previous year. These included 472 under the BTEC scheme (24% less than 1992-1993), 89 under the Northern Australian Quarantine Strategy (NAQS: + 89%) and 87 for export testing. Specimens from cattle comprised one third of the cases investigated (817). In addition 586 cases were from dogs, 195 from poultry and other birds, 131 from horses, 125 sheep, 121 cats, 103 insects, 96 buffalo, 72 native fauna, 66 crocodiles, 39 goats and 28 from pigs. Submissions from camels, fish, rabbits, reptiles, exotic fauna, banteng, pearl oysters and other miscellaneous specimens (such as water, stock dips, foodstuffs, etc.) represented, for each type, less than one per cent of total cases.

**BACTERIOLOGY AND PATHOLOGY - ROUTINE TESTING**

#### Export Certification

Tests were done on 13792 serum samples for export certification of animals. These were:

- Cattle: 13522
- Buffalo: 120
- Horse: 28
- Camel: 25
- Goats: 97

Certification for freedom from *Perkinsus* infection was done on four batches of pearl oysters.

#### Brucellosis and Tuberculosis

**Brucellosis**

Serological testing for brucellosis under the BTEC program ceased in the Northern Territory on 31 December 1991. Consequently, there was no testing under this scheme in the year July 1993 to June 1994. A small number of brucellosis tests were done for the purpose of export certification.

**Tuberculosis**

For the year ended 30 June 1994, specimens were received from 472 animals for investigation for tuberculosis, 131 being from abattoirs and 341 from field investigations.

**Bacteriology**

All 472 animals were investigated bacteriologically with a total of 1065 mycobacterial cultures. *Mycobacterium bovis* was isolated from tissues of 20 animals while cultures from 61 animals were contaminated and, consequently, could not be confirmed either way. A wide variety of bacteria and several fungal organisms were isolated on general bacterial culture from many of the animals.
Histology
Tissues from 142 of the animals were examined histologically with the results:

- Consistent with TB: 22
- Club-forming granuloma: 65
- *Rhodococcus equi* infection: 9
- Fungal granuloma: 5
- Parasitic: 5
- Neoplasm (cancer): 6
- Undetermined: 15
- No lesion detected: 5
- Miscellaneous: 7

*** General Pathology

Histology
Organs and tissues from 743 submissions were processed for microscopic examination. A total of 2930 tissue blocks were processed and sections stained with routine diagnostic dyes (haematoxylin and eosin) while a further 630 of these were stained using special dyes for detection of micro-organisms, identification of cell or tissue types, demonstration of specific changes or chemical processes. A grand total of 3560 tissue sections were prepared, examined and reported.

Bacteriology
A total of 3010 samples from 814 general accessions were submitted for microbiological investigation, with 755 for microscopic examination and 2873 primary cultures prepared.

Clinical Pathology
During the year 760 blood samples were submitted for haemograms, 718 sera for biochemical analyses, there were 143 submissions for cytologic evaluation and 84 for urinalysis. Almost all haematology, biochemical and urinalysis investigations require measurement of ten or more factors or analytes.

Parasitology
Worm egg counts and coccidial oocyst counts were done on 951 faecal specimens. Identification and/or counts of internal or external parasites were required in a further 110 investigations. While this may involve identification of a single parasite from an individual host animal, in most investigations the identification and/or counting of several parasites from more than a single host is required.

Serology
Diagnostic (non-export) serologic tests were carried out to detect evidence of infection with specific diseases as follows:

- Melioidosis: 125
- Toxoplasmosis: 15
- Johne’s disease: 117
- Chlamydioidis (psittacosis): 1
- Tick fever - babesiosis: 520
- - anaplasmosis: 100
- Leptospirosis: 312
- Caprine arthritis/encephalomyelitis: 60
VIROLOGY

● ● ● NT Sentinel Herds

Project period: 1993 - 1994
Project Officer: L Melville
Project Location: CPRS, BARC, DDRF, VRRS, AZRI, KRS, Newcastle Waters Station

Objective:
Sentinel herds have been established at various sites around the NT to:
- Identify any new arboviruses entering Australia
- Establish the spread of arboviruses throughout the NT.
- Attempt to establish the interaction between virus activity and seasonal conditions to improve risk assessment.

Background:
Since the isolation of BLU 20 (bluetongue virus) in 1975 and the establishment of the Virology Laboratory in Darwin, an additional 7 serotypes of bluetongue have been isolated, 5 of these only in the NT. Serology indicates that 4 of these have arrived since 1982. In addition to the bluetongue serotypes, 4 viruses in the Ephemeral Fever (BEF) group and 1 Palyam have also been initially isolated in Darwin. This indicates that introductions of new arboviruses are ongoing and programs are necessary to monitor the entry and spread of these viruses and others, including Epizootic Haemorrhagic Disease (EHD).

Results:
- CPRS
  Following good rainfall during the wet season, a moderate level of arbovirus activity occurred. A total of 236 viruses were isolated from the following groups:

  Bluetongue: type 1 March-April-May 93
  untyped 9

  EHD: type 5 January-February 29
  untyped 24

  Simbu 8
  Akabane 3
  Un typed 2
  Ungrouped 72

  Monthly serology also indicated BEF virus activity in February and Palyam from January-March.

- BARC
  Monthly serology indicated the following activity:
  Bluetongue type 1 March-May
  Simbu January-August
  BEF March-April
  EHD March-April
  Palyam December-January

- DDRF
  Monthly serology indicated the following activity:
  BEF February
  Palyam February
  Simbu November-February
  EHD August-February

- KRS
  Monthly serology indicated Simbu, BEF and EHD activity (March-July), bluetongue (December-July), and Palyam (March-May).
Apart from a low level of BEF seroconversions in January, May and July, no other arbovirus activity was detected throughout the year.

This herd was bled in August 1993 only, when there were no serum reactors to arboviruses.

### Monitoring for the Introduction of Avian Influenza (AI) and Newcastle Disease Virus (NDV)

**Project Period:** 1993-1994  
**Project Officer:** A. Janmaat  
**Project Location:** Coastal communities, Katherine

**Objective:**  
To establish poultry sentinel flocks which are bled on a regular basis and tested for antibodies to AI and NDV to detect the introduction of pathogenic virus.

**Background:**  
The exotic pathogens of poultry, AI and NDV, are considered to have high risk for introduction into northern Australia. Previous surveys have been conducted in Western Australia and Queensland, but there has been no regular surveillance in the NT.

**Results:**  
Sentinel flocks were located at CPRS, Pularumpi, Palumpa, Murganella, Smith Point, Howard Springs, Gove, Leanyer and Katherine. Testing indicated that an apparently non-pathogenic NDV had been circulating in the Darwin area, Murganella and Katherine.

Monitoring of magpie geese showed a low level of NDV activity.  
Sera from this monitoring is also being used to detect alphavirus and flavivirus activity as part of Health Department surveillance for these viruses.

### Virus Isolation from Insects

**Project Period:** 1993 - 1994  
**Project Officer:** R. Weir  
**Project Location:** BARC

**Objective:**  
To improve knowledge of the role of insects in transmission of viral disease by isolating viruses from pools of insects.

**Background:**  
Vectors are critical to the spread of arboviruses. Identifying insects which may play a role in viral transmission improves knowledge about the epidemiology and control of diseases caused by these viruses.

**Results:**  
Isolations of viruses from mosquitoes for the year ended June 1994 were:

- Total isolates: 61
- Ross River Virus: 4
- Barmah Forest virus: 2
- Sindbis: 8
- Untyped: 47

Further study of the previously "unknown" viruses isolated from mosquitoes over the previous 10 - 12 years
has allowed an updating of the provisional serogrouping as reported last year, as follows (number in brackets, last year's figure):

Wongorr 137 (140); Wallal 9 (9); Warrego 10 (10); Eubenangee 4 (4); Corriparta 18 (18); Falyam 1 (1);
Bluetongue 5 (5); Mapputta 8 (8); Kowanyama 4 (4); Alpha-1, 20 (20); Alpha-2, 32 (30); Alpha-3, 0 (2);
Flavivirus 1 (5); Uukuvirus 0 (2); Oakvale 1 (0); Edge Hill 2 (0); Kunjin 2 (0); Unknown 9 (61).

The 61 previously unidentified ("unknown") viruses have been resolved further as follows:

Wongorr-related 21; Bunya-like virus 11; Rhabdo-like virus 1; orbi-like virus 9. Ten of the sixty-one viruses either were found to be non-viral cytopathogens, or have died out in storage or subculture and thus cannot be further identified, leaving only nine (9) viruses as yet unidentified.
RESOURCE PROTECTION DIVISION

PLANT PATHOLOGY BRANCH

• • • Disease Diagnostic Service

Project Period : Ongoing
Project Officers: R Pitkethley, B Condé, J Duff, L Ulyatt and M Connelly
Project Location: BARC

The plant disease diagnostic service was maintained as a service for primary producers, quarantine and research workers. A significant number of home garden enquiries was also handled.

A total of 501 diagnostic cases was handled during 1993-94. This figure does not include those telephone and personal enquiries which were not accompanied by specimens.

• • • Plant Disease Reference Collection and Host Index

Project Period : Ongoing
Project Officers: R Pitkethley and L Ulyatt
Project Location: BARC

The reference collection of NT plant diseases was maintained and further developed. New specimens were added to the collection in the course of normal diagnostic activities and also as a result of surveys. Interesting new accessions included:
- Carnation mottle virus on carnation;
- Oidium sp., powdery mildew on mango;
- Uromyces dianthi, rust on carnation;
- Phomopsis sp. associated with twig and branch death of rambutan probably caused by lightning;
- Tomato big bud mycoplasma on Emilia sonchifolia, thistle.

In addition to new accessions, records of NT diseases held at Herb. DAR, the herbarium of the Biological and Chemical Research Institute, Rydalmere NSW were obtained. The Rydalmere collection forms a part of the National Collection of Plant Pathogens. Records from Herb. DAR that were not already represented in the NT collection were added to the Darwin database.

In 1993-94, 313 accessions (including those from Herb. DAR) were added to the database to give a total of 2865.

The new Host-Index of Plant Diseases in the Northern Territory is now close to completion. The host-index has been developed as a word processor document and is nearing publication stage.

• • • Citrus Canker Survey

Project Officer : R Pitkethley, B Gower (QIB)
Project Location : BARC

Surveys of citrus in the Lambell's Lagoon area near Humpty Doo continued following the detection of the second citrus canker infection in the area in May 1993. As agreed by the SCARM Citrus Canker Consultative Committee, surveys were carried out at two-monthly intervals during the dry season and at
monthly intervals during the wet season. No further symptoms of citrus canker were detected in the course of the surveys of all remaining citrus in the Lambell’s Lagoon sub-division. Citrus scab, caused by the fungus *Sphaceloma fawcettii* var *scabiosa*, was confirmed on one property. Scab can sometimes be confused with canker.

A preliminary investigation of possible alternative hosts of the citrus canker bacterium among native vegetation of the citrus family (Rutaceae) and related families was started. Liaison with botanists at the Conservation Commission of the NT established the following Rutaceous species might occur in the Lambell’s Lagoon sub-division or surrounding areas:

- *Melicope elleryana* (F. Muell.) T. Hartley (formerly *Euodia elleryana* F. Muell.)
- *Glycosmis trifoliata* (Blume) Sprengel
- *Microcitrus* sp. McKean
- *Micromelum minutum* (Forster f.) Wight & Arn.

Advice was that, of the above species, only *Microcitrus* sp. would be expected to occur in dry woodland such as the Lambell’s Lagoon subdivision. The other four species would be expected to occur only in permanently moist areas such as vine thickets and rainforests. Although *Microcitrus* sp. has been seen in other locations in the Darwin-Humpty Doo area, it has not been observed in the Lambell’s Lagoon area in the course of surveys since 1991. Surveys revealed *Melicope elleryana* growing as an ornamental on two properties and *Murraya* spp. on several properties.

A rainforest area known as Black Jungle, about 3 km to the north west of the subdivision, was surveyed on 14 October 1993. Two Rutaceous species were found, namely *Melicope elleryana* and *Glycosmis trifoliata*.

The host status of the above species with respect to citrus canker is not known, but a search of the literature revealed that *Microcitrus australis* has been observed, with lesions produced by natural infection. Other species of *Microcitrus*, *Euodia* (*Melicope*), *Glycosmis* and *Murraya* are known to produce lesions after artificial inoculation with *X. campestris* pv. *citri*. The preliminary investigation has suggested that further work may need to be done to rule out the possibility of citrus canker surviving on non-citrus hosts.

*Horticultural Crop Disease Surveys*

**Project Period:** Ongoing  
**Project Officers:** B Conde, L Ulyatt, J Duff and R Pitkethley  
**Project Location:** BARC

**Banana nematode survey**  
Commercial banana plantations in the Darwin, Adelaide River and Katherine areas were sampled to determine the species of nematodes present, their distribution and to assess their significance.

Root knot nematodes (*Meloidogyne* spp.) were present on all blocks tested but did not appear to be significantly affecting growth. Burrowing nematode (*Radopholus similis*) was present only at two locations and in low numbers. The spiral nematode *Helicotylenchus multicinctus* was relatively common and was causing significant damage on one property.

Four other species were also found in very low numbers. These were *Helicotylenchus dihystera*, *Hoplolaimus seinhorsti*, *Rotylenchus reniformis* and a *Pratylenchus* sp.

**Mango dieback survey**  
As a result of a number of reports of dieback-like conditions Plant Pathology Branch has initiated investigations into the symptomatology, associated microorganisms and probable causes. The investigation sought to determine whether one or more than one cause was involved in the various cases reported.
The cause of at least one instance of dieback was related to prolonged water-logged conditions. Although the fungus *Botryodiplodia theobromae* was isolated from two affected trees it is not considered the cause. This fungus is very widespread among mangoes in tropical areas and is a common invader of weakened or stressed mango tissues.

In two other instances circumstances point to lightning as the cause. Typically in these cases a central tree was severely damaged or dead and adjacent trees showed lesser damage on the proximal side. There was no evidence of progression of the symptoms. Tissues below the bark were darkened and emitted a vinegar-like odour. In one of these two instances a nearby rambutan showed a vertical dieback lesion proximal to the central mango tree. This added evidence for lightning as the cause rather than a pathogen.

As well as *Botryodiplodia theobromae*, a number of other fungi including *Fusarium* sp., *Aspergillus* sp., *Penicillium* sp. and *Macrophomina phaseolina* have been isolated from symptomatic mango trees. Interpretation of data from observations and investigations is continuing but it can be concluded that more than one condition exists rather than a single new disease.

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**Virus Diseases of Horticultural Crops**

**Project Period**: 1989-1993 (review)
**Project Officers**: B Condé and M Connelly
**Project Location**: BARC

**Tomato viruses**

Work on the Australian tomato leaf curl virus (ATLCV) continued as a cooperative project with CSIRO. Following earlier successful whitefly transmissions of the virus, work continued with the aim of establishing a reproducible system. Transmission was confirmed by backgrafting to Datura or tomato.

During the course of the work a second virus was found in a wild solanaceous plant. When inoculated into tomato cv Grosse Lisse this virus produced symptoms which were quite distinct from those of ACTLV. It was also found to infect *Datura stramonium*, *Nicotiana tabacum* cv Xanthi and wild Malay eggplant, but was symptomless in these hosts.

In contrast to ATLCV which has only been transmitted with difficulty by whiteflies, the new virus has been transmitted readily by whitefly. Simultaneous transmission of this virus and ATLCV has been shown to occur as demonstrated by backgrafting. The fact that the two viruses are transmitted together is evidence that they are not closely related. The new virus has not yet been named but has been temporarily designated "tomato feathery shoot virus" or TFSV.

**Sweet potato virus**

Eight varieties of sweet potato were indexed for sweet potato feathery mottle virus (SPFMV) by grafting onto *Ipomoea setosa* indicator plants. One of these varieties, NC-3, was held by DPIF Horticulture and also by a private grower. Of the eight varieties, SPFMV was detected in only NC-3 from Horticulture Division. The NC-3 held by the private grower indexed negative for SPFMV. Queensland DPI recently indexed their sweet potato varieties and found NC-3 to be the only one infected with SPFMV. The NC-3 held by Horticulture Division was recently obtained from Queensland and, since NC-3 was the only variety found with virus here, it is indicated by backgrafting. The fact that the two viruses are transmitted together is evidence that they are not closely related. The new virus has not yet been named but has been temporarily designated "tomato feathery shoot virus" or TFSV.

A trial was done to compare the yields of two varieties of sweet potatoes, NC-3 and Rojo Blanco with and without virus. Clean NC-3 was obtained from the tissue culture program at QDPI. A plant of Rojo Blanco was infected with the virus by grafting infected NC-3 scions onto it. Results are summarised in the following table:
Although the trial was not laid out in a manner which could be analysed statistically, two deductions can be made:
1. NC-3 appears to have a high level of tolerance to the virus and did not show any yield reduction.
2. Rojo Blanco appears to have less tolerance to the virus and has thus incurred a slight yield loss.

Control of Orchid Blossom Disease

Project Period: 1992-94
Project Officers: J Duff, M Connelly and L Ulyatt
Project Location: BARC

The second season of this trial was completed in 1993-4. The project was set up to assess a range of fungicides for control of orchid blossom spot caused by the fungus Carvularia eragrostidis.

The trial demonstrated that flower spotting is dramatically reduced if orchids are protected from rain by means of an impervious roof. Incidence of spotting was greater in a shadehouse without a rain-proof roof, and white-flowered types were much more affected than coloured ones.

The use of fungicides was shown to be necessary to achieve satisfactory control even with rain protection. The trial showed that Rovral Liquid®, Rovral Aquaflo® and Rover® were the most effective fungicides.

Database of Registered Chemical/Crop/Disease Combinations

Project Period: 1990-93 (with ongoing updates)
Project Officer: R Pitkethey
Project Location: BARC

The "RegKem" database was further updated and now has over 2000 registered uses. The computer database provides easy access to all registered chemical/crop/disease combinations for Plant Pathology and extension staff. The information in this database is derived from the registrations database and from sample labels from the office of the Pesticide Registrar. It will be updated as new chemicals are registered or as changes are made to existing registrations.
ENTOMOLOGY BRANCH

Entomology Branch undertakes routine identification of plant insect pests, surveys insect populations, investigates methods of monitoring and control and advises on control measures. It also provides certification for quarantine purposes.

CONTROL OF SWEET POTATO WEEVIL PESTS

<table>
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<tr>
<th>Project Period</th>
<th>1993 - 1996</th>
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<tr>
<td>Project Officers</td>
<td>K Blackburn, M Traynor, E S C Smith and M.J.Neal</td>
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<tr>
<td>Project Location</td>
<td>CPRS</td>
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**Objective:**
To examine the effectiveness of several cultural and insecticide treatments applied to field sweet potatoes against sweet potato weevil and giant termites.

**Background:**
Due to the unavailability of staff and the small number of sweet potato field crops, only observational work on this problem was conducted prior to June 1993. Currently there is only a single commercial producer of sweet potato in the NT and losses from weevil have been slight but significant. However, experimental plots at CPRS have suffered substantial damage from both weevil and giant termites.

In August 1993, a replicated trial to test several cultural and chemical control methods against both pests (but particularly sweet potato weevil) was established by the Horticulture Division on infested land at CPRS. The crop was harvested earlier than anticipated due to heavy attack by magpie geese and the treatments were assessed at harvest by both the Horticulture Division and the Entomology Branch.

**Results:**
A single-factor ANOVA test indicated that differences in weevil damage between treatments were almost significant at the 5% level. This indicated that treatment with chlorpyrifos would reduce the level of damage. Dipping of planting material alone was not sufficient to prevent damage and soil incorporation was less effective than foliar sprays of the chemical.

The results suggest that dipping of planting material plus foliar sprays at (say) 5 and 10 weeks would most likely give adequate control of weevils but would have little effect on giant termites.

A further trial to confirm these observations may be conducted during the 1995 growing season.

FACTORS AFFECTING SCALD DAMAGE IN HOT WATER TREATED MANGOES

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<th>Project Period</th>
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<tr>
<td>Project Officers</td>
<td>E S C Smith, M J Neal and S Griffiths</td>
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<tr>
<td>Project Location</td>
<td>BARC, CPRS, Growers’ properties</td>
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**Objective:**
To determine the pre-harvest conditions which can predispose mango fruit to suffer scald damage when exposed to an on-farm hot water treatment effective against fruit flies and post-harvest rots.

**Background:**
A Hot Water Dipping (HWD) system for mangoes has been developed over the past five years. The treatment will satisfy quarantine security for fruit flies, significantly reduce the incidence of post-harvest rots, accelerate ripening and has several other advantages over the currently accepted methods of preparing mangoes for interstate trade.
The treatment has been developed for on-farm use and will be preferred by consumers since it eliminates post-harvest chemical use. It is likely that the technique would also be accepted in international trading with mangoes.

The main drawback to general acceptance of the technique by NT growers has been the possibility of fruit suffering heat scald. In the past, this damage has been severe enough to prevent marketing of the fruit. Experiments conducted during the 1992 mango season, showed that scald damage was strongly correlated with pre-harvest rainfall and that the damaging effects could be ameliorated by field irrigation practices. In particular, pre-harvest rainfall had minimal effect on HWD fruit from "droughted" trees which had received no irrigation for 4 weeks prior to harvest. Fruit from these droughted trees could be HWD within 5 hours of picking without significant scalding.

It was intended that the 1993 HWD work concentrate on:
. confirming the individual and interactive effects of pre-harvest rainfall and field irrigation on HWD fruit;
. testing the potential of HWD fruit for non-refrigerated transport to Southern markets;
. proving the effectiveness of the HWD method against the Queensland stem end rot fungus;
. a preliminary examination of possible methods for early detection of scald in HWD fruit;

Results:
Although the season was not conducive for large scale experimentation, scald could again be induced by pre-harvest rainfall and the ameliorating effect of reducing irrigation prior to harvest was shown to apply to both Darwin and Katherine fruit. The pre-harvest rainfall effect reached a maximum 2 days after treatment and the rainfall effect appeared to be cumulative. In addition, an analysis of unexplained scald results from previous years’ experiments has now largely been linked to significant rainfall on the days preceding fruit harvest.

HWD fruit which underwent simulated un-refrigerated transport conditions to Southern markets performed extremely well in experiments conducted by the Agricultural Engineering Group in Katherine. These tests indicated that the HWD fruit would ripen at average temperatures well above 26°C and were of very acceptable market quality.

The Queensland stem end rot fungus *Dothriella dominicana* was completely controlled in HWD fruit until they ripened but some infections then became evident in the days following physiological ripeness. Other experiments on disease expression revealed that anthracnose disease could become evident in HWD fruit in the days following ripeness and that dipping fruit in DC-Tron without subsequent HWD treatment (which actually enhanced scalding) or post-harvest fungicide treatment, would promote the development of anthracnose symptoms.

Both skin penetrometer and fruit respiration measurements indicated that heated fruit were significantly different from control fruit. However, there was considerable overlap between fruit which was undipped; that which was heated but undamaged; and fruit which was heated and subsequently exhibited scald symptoms. The overlapping measurements indicated that these methods would not be suitable for early field detection of scalding without substantial refinement.

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**Attempted Eradication of Parlatoria Scale on Date Palms in Central Australia**

**Project Period:** 1989-1995

**Project Officers:** M J Neal, S Griffiths, E S C Smith and AZRI staff

**Project Location:** AZRI, Growers’ properties, Alice Springs

**Objective:**
To control populations of parlatoria scale on date palms using chemical treatment and, if feasible, attempt eradication of this pest from Central Australia.
Background:
Parlatoria scale was first introduced to the Alice Springs area in the 1950's and a survey during 1990 found that the pest was restricted to palms in the Alice Springs area or other areas to which infested offshoots had been moved since the late 1950's. During 1990-1991 trials to monitor the effectiveness of chemical treatments on infested palms at AZRI and Arid Gold Farm at Deep Well were established.

Palms sprayed regularly with maldison or dimethoate plus white oil or injected with monocrotophos showed effective control of scale at Arid Gold Farm and AZRI respectively. Both treatments significantly reduced insect numbers to negligible levels by July 1991 and eradication appeared possible. Unfortunately staff changes at AZRI prevented the monitoring and control programs being continued and numbers of scale resurged at both sites.

Insecticide treatments were re-commenced on a regular basis at both AZRI and Arid Gold Farm in March 1992 and have again reduced populations to very low levels.

Results:
The program has been continued by AZRI staff members and it is still hoped that this pest may be eradicated from the infested properties over the next 2-3 years. It is important that strict hygiene is enforced over this period to prevent the re-entry of the pest. Spread of the scale over the past several years has occurred almost entirely through the activities of the two commercial producers in the area.

There is a very low but persistent infestation on palms in all areas treated and the Entomology Branch monitors populations from samples sent by Horticulture staff.

Observation Trial on Mango Seed Weevil Control by Physical Barriers

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<th>Project Period</th>
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<tr>
<td>Project Officers</td>
<td>J D Duff</td>
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<tr>
<td>Project Location</td>
<td>BARC</td>
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Objective:
To examine the possibility of applying a teflon tape (Enviro Safe®) to the base of mango trees to act as a physical barrier against mango seed weevil (Sternochaetus mangiferae) crawling up the trunks and to determine the tape's effectiveness in preventing movement of ants into the branches.

Background:
The current recommendation for mango seed weevil (MSW) control in mangoes is to apply insecticides to tree trunks within 4 weeks of fruit set. Alternative treatments against this pest would be very desirable. Several species of ants attend scales on mango leaves and by reducing numbers of ants, greater parasitism of scales would likely ensue.

Method:
A row of trees in the mango orchard on the Berrimah Research Farm was selected and the teflon tape was applied both to the base of each tree and to the larger limbs. Two layers of the tape were used to act a barrier to the MSW and ants moving along the trunk and main branches. The tapes were placed in November, at the conclusion of harvest, and tested for effectiveness and durability during the wet season.

Results:
At the time of application, MSW could be seen on the lower limbs. Some of the beetles, when dislodged, flew to neighbouring trees. Thus, the effectiveness of the tape was questionable even at the outset as the MSW could easily fly over the tape barrier. The effectiveness against the ants therefore assumed higher priority. Immediately after the tape was in place ants had difficulty in crossing the tape but, within a week, the ants had worn a track across the tape either by sheer numbers wearing the coating from the tape or possibly by chewing the Teflon. The tape also started to separate from the trunk of the tree even after a few weeks, allowing access for the weevils beneath the supposed barrier.

Further designs of the tape will be assessed in the field.
Arthropod Pests of Ornamental and Amenity Plants in Nurseries

Project Period: 1992-1995
Project Officers: J D Duff, M J Neal, S Griffiths and E S C Smith
Project Location: Top End Nurseries

Objective:
To compile a checklist of mites and other pests on nursery plants in the Northern Territory.

Background:
The last nursery survey conducted in 1992 revealed mites to be the most common pest problem attacking a wide range of host plants. It was felt that a more detailed survey conducted over a 12 month period to determine some aspects of the biology and ecology of the mites would be appropriate. As in the first survey, other insect pests would also be monitored during such visits.

Method:
Of the 22 commercial nurseries initially surveyed, 11 were chosen for re-investigation on the basis that they had experienced the greatest range of insect and mite problems. All were located within the Darwin region. However, four Alice Springs nurseries were also visited during April.

Data on the operational aspects of the nurseries, their perceived pest problems, samples and records of insect and mite species present, their densities, host range and host damage were recorded.

The surveyed nurseries were spread across the three sales categories catering for (a) mainly retail sales, (b) mainly wholesale or, (c) both. Each nursery, with the exception of those in Alice Springs were surveyed at four monthly intervals.

Results:
The survey found that mites were still the most common pest problem encountered in the nurseries, followed by mealy bugs, scale insects and aphids. As expected, mites were not as numerous during the wet season surveys.

The release of the predatory mite *Phytoseiulus persimilis* in the shade house at one local nursery produced excellent results within two weeks. However, the success of these predatory mites varies between nurseries and more work is required to determine the effectiveness of the predatory mites under other Darwin conditions.

The Integrated Pest Management Workshop during December 1993 has influenced growers' attitudes to chemicals and the use of natural insect control measures. Although the majority of the nurseries surveyed still used insecticides, most now use spot applications rather than blanket sprays. Managers understood the need to reduce their reliance on such chemical control and to encourage the survival of natural predators in their nurseries. The occurrence of predatory ladybirds in many nurseries was particularly pleasing.

A final survey remains to be conducted to complete this project.

Eradication of the Orchid Weevil in the Northern Territory

Project Officers: E S C Smith, M J Neal and S Griffiths
Project Location: One Top End orchid growing property

Objectives:
To determine the distribution of orchid weevil and if feasible, attempt an eradication of this pest from the Northern Territory.
Background:
The orchid weevil, *Orchidophilus aterrimus* is a pest of *Dendrobium* orchids in SE Asia, Hawaii and North Queensland. After detection in the NT, it was suspected to occur only on one property in the NT, having been introduced from North Queensland about six years ago. The very restricted distribution was confirmed and an eradication programme was commenced in October 1992.

Method:
Since only a single infestation occurred in the NT and was confined to a relatively isolated property, the decision to attempt eradication of this pest was a simple one and *O. aterrimus* was declared a quarantine pest in September 1992.

The eradication program involved strict hygiene conditions, a pesticide dipping and spraying program and regular plant and property inspections.

Results:
Since June 1993, the shade house has been regularly inspected and treated both inside and out. There has been no evidence of the weevil’s presence over the 22 month period since the eradication program commenced. The chemical applications ceased in early August 1993 but regular property inspections have continued. If no further sightings are made, it is probable that a declaration of eradication and withdrawal of the quarantine restrictions on the property will take place at the end of the next wet season.

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**Rearing Methods for the Melon Thrips *Thrips palmi***

**Project Period:** 1992 - 1995

**Project Officers:** K Hergstrom, H H Brown and L Zhang

**Project Location:** BARC

**Objective:**
To develop an *in vitro* rearing method for *T. palmi* which allows the majority of larvae to survive through to the adult growth stage.

**Background:**
In order to study the effects of chemicals, nutrition and environmental factors such as precipitation and high humidity on individual thrips, it is necessary to develop an *in vitro* rearing technique which enables the majority of specimens to complete their life cycle.

**Materials and methods:**
A rearing method developed in China (Wang & Chu, 1989) had been tried, but found to produce a low survival rate. A variation of the Chinese method was tested by placing whole leaves as the nutrient source for the thrips in moistened cotton wool into aerated plastic yials. Another method tested involved floating leaf discs on a nutrient solution in petri dishes.

**Results:**
Rearing thrips in vials was rejected in 1993, primarily because the second instar larvae tend to move off the leaf in search of a place to pupate, get caught in the cotton gauze and die. Larvae were also lost in the petri dishes when they moved off the leaf and drowned, or the leaf floated to the petri-dish edge, and the larvae crawled off onto the wall of the dish. Using an adhesive and a micro pin to fasten the leaf discs to the middle of the petri-dish has prevented some larvae wandering, and from disappearing. We found survival greatest using the lower surface of cucumber leaves. We are now testing plastic food containers with greater depth than petri dishes, as this will prevent movement onto lids. These containers also seal tighter, so we expect to lose fewer thrips adults.
Thrips palmi trap monitoring and produce inspection

**Project Period**: 1991 - 1995
**Project Officer**: K Hergstrom, E Crowson and S Griffiths
**Project Location**: Growers' properties in the Darwin area, Katherine and Lake Bennett

**Objective**: To develop and maintain a detection system for *Thrips palmi* to enable area or property freedom certification for export of horticultural produce and nursery stock.

**Background**: From May 1991 to November 1993, interstate quarantine officials accepted weekly monitoring using the sticky-board trapping method to prove area and property freedom and allow *T. palmi* host produce from properties to be certified free of *Thrips palmi* for export and sale interstate. Since November 1993, the protocol accepted interstate for imported host produce of melon thrips was radically altered, and property freedom is no longer accepted if that property is within 50 km of a known infestation of melon thrips. However, the acceptance of specified disinestation techniques and inspection of some produce has given some growers from the Darwin area access to markets in WA and SA, whilst QLD and NSW have removed their barriers entirely.

**Results**: Alice Springs/Ti Tree region - Monitoring for area freedom commenced in the central arid zone in July 1991 and has continued since that time with no loss of area freedom status. Katherine region - monitoring commenced in Katherine in late May 1991. The area freedom status for the whole region was lost when one property trapped *T. palmi* in September 1992. That property has since had its property freedom reinstated.

**Darwin area property monitoring 1991-June 1993 Summary**
From mid-May 1991 to June 1993, 58 commercial properties in the Darwin rural area were trapped in order that owners could obtain certification of property freedom to export restricted produce interstate. Of the 1337 trap catches recorded over this period only 50 (=3.7%) were positive for *T. palmi*. The trend shown over the two year period (1991-3) was that thrips would move onto ‘clean’ properties towards the end of the dry season and occasionally during the start of the wet season. Once the wet season was established, thrips populations died out (provided growers ceased planting host crops).

**Property Monitoring July 1993 onwards**
For the period 1/7/93 to 27/7/93 there were 28 properties monitored in the Darwin, Batchelor and Lake Bennett areas. A total of 84 traps were examined during that period and no *T. palmi* were detected.

From 28/7/93 to 28/10/93 a total of 240 traps were inspected on 20 properties resulting in 2 positive identifications. Both were from vegetable growers.

Towards the end of October 1993, Queensland and New South Wales lifted their restrictions on *T.palmi* hosts which brought down the number of monitored properties to five (5) for the period 29/10/93 to 9/12/93. No positives were identified during that period.

From 10/12/93 to 27/1/94 two (2) properties were being monitored and from the 28/1/94 to 10/3/94 one vegetable property was being monitored although it was not producing at the time. Monitoring was to determine if *T. palmi* were present in the native weed population during the wet season. No *T. palmi* were detected.

From 7/6/94 to the present, 4 traps are being monitored weekly on one (1) property in the Lake Bennett area, this is to retain ‘property freedom’ status. To date no *T.palmi* have been detected.

**Southern Region monitoring**
From 1/7/93 to 10/11/93 two (2) properties were monitored in the Ti Tree area. No positives were found. Ti Tree became a ‘free’ zone at the end of October 1993 and monitoring was suspended.
Katherine Region monitoring
From 1/7/93 to 14/9/93 there were 7 properties in the region being monitored. No positives were detected.

From 27/3/94 to 30/06/94 2 properties were monitored with 5 traps each in the Katherine area. These are inspected at fortnightly intervals to maintain a 50 km radius ‘area freedom’ zone for export purposes. No T. palmi have been detected.

Inspections and Treatments
From 4/2/94 to 14/7/94 Entomology Section carried out or supervised a total of 69 inspections and/or treatments to satisfy the import requirements of South Australia and Western Australia.

Publication:

Thrips palmi Disinfestation

Project Officers: K Hergstrom, H H Brown
Project Location: BARC and growers’ properties

Objective:
To develop methods for Thrps palmi disinfestation of horticultural produce and nursery stock acceptable to interstate quarantine authorities.

Background:
During the 1991-92 growing seasons, four States imposed quarantine restrictions on NT horticultural produce and in one case, nursery stock. To enable producers to survive in the long term, a suitable disinfestation method was sought to allow interstate export when traps on properties indicate the presence of T. palmi. Initial disinfestation trials tested on artificially infested produce in 1991-2 were discouraging. In May 1993 the Interstate Plant Health Regulation Working Group deliberated that it would accept any post-harvest washing technique shown to reduce melon thrips levels on fruit taken from infested crops to insignificant levels (i.e. complete disinfestation of 600 fruit). Trials to test the effects of hand-washing horticultural produce taken from infested crops began in May 1993.

Disinfestation methods, materials and results:
Trials from May to November 1993 tested the effect of hand washing produce taken from crops infested with melon thrips. Testing was done at the international quarantine inspection rate (600 fruit per variety). Handwashing was found to successfully disinfest beans, pumpkins, squash, and smooth-skinned melons. Cucumbers and tomatoes remained uninfested before and after treatment. However, zucchini and rockmelons remained infested after treatment. This data was acceptable to interstate quarantine authorities, and handwashing of beans, cucumbers, pumpkins, squash, smooth-skinned melons and tomatoes became an approved disinfestation technique included in the melon thrips protocol for exporting produce interstate.

Biology and Ecology of Thrps palmi

Project Officer: K Hergstrom, H H Brown and L Zhang
Project location: BARC and growers’ properties

Objective:
To undertake research into the biological and ecological aspects of T. palmi in the dry tropics and to develop an efficient integrated management system for its control.
Background:
In order to study the interactions of the melon thrips with its environment in the NT, field populations have been monitored since 1991 at a Berry Springs property with an endemic melon thrips problem.

Through monitoring populations of melon thrips we hope to learn more about its biology and interactions with its environment. By observing predation and parasitism rates in the laboratory we seek to identify the relative importance of several species of natural enemies, and assess their potential use for biological control. The information gained in ecological studies is essential for economic management of this pest.

Methods and results:
By comparing thrips populations on 74 crops surveyed from 1991-3 the relative attractiveness to melon thrips of various host crops was assessed.

During the 1993-4 season both indoor and outdoor colonies were successfully established to draw thrips from for experiments, and attract natural enemies. Results indicated a wide diversity of potential thrips predators present, including several spider species of the Araneid, Thomisid and Salticid families, two Amblyseius species (predatory mites), Orius tanillus, Campylomma australasia and a Geocoris sp. (all predatory bugs), and a predatory thrip species of the Phlaeothripidae family (to be identified). A comparison of their predation of melon thrips in the laboratory has found that the predatory mites and predatory thrips can eat 1-2 thrips per day per adult, the spiders eat up to 6 thrips per day, and the Orius predatory bugs may eat up to 24 thrips per day per adult. Although it appears that the predatory bugs hold the greatest prospects for biological control, their populations have remained small in comparison to the predatory mites and predatory thrips under Darwin’s hot/humid weather conditions (and regular spray schedules).

A fungus isolated from dead thrips in the 1993 wet season was identified as a Cladosporium sp., but primary pathogenicity was not confirmed in laboratory tests. Several other species of fungus have also been isolated from dead thrips - their pathogenicity will be further investigated.

In February a parasitic wasp was isolated from a melon thrips culture. The parasite has been identified as Goetheana shakespearei Girault. This is the first time this species has been found to parasitise Thrips palmi. In Ghana it attacks mainly the red-banded thrips Selenothrips rubrocinctus, and it is probable that the parasite came from the red-banded thrips populations at Berrimah. In the laboratory % parasitism appears to be low - 8%. We aim to test this in the field.

Alternative Chemicals for Control of Melon Thrips

Project Period: 1993 - 1995
Project Officers: K Hergstrom and L Zhang
Project Location: BARC

Objective:
To find an alternative chemical control other than promecarb (soon to be removed from the market) for melon thrips, preferably one targeted to this pest species that will cause minimal effects on beneficial insects present.

Background:
Promecarb is the only chemical registered specifically for control of melon thrips in the Northern Territory. Unlike other commonly used agrochemicals tested, promecarb had a reasonable efficacy against melon thrips (greater than 80% mortality). Its disadvantages include that its effect is non-specific and does not last longer than a week, its withholding period is very long (28 days), and by the end of 1994 it is being withdrawn from sale by the manufacturer.

A readily repeatable in vitro rearing technique had been developed in the laboratory which kept the mortality of control specimens below ten percent after 2 days. It was decided to test the efficacy on melon thrips of any readily available chemicals of low mammalian toxicity.
Materials and methods:
Leaf discs cut from cucumber plants sprayed with various test chemicals, including distilled water as a control, were placed in individual petri dishes (5 replicates per treatment). To each replicate 20 first or second instar nymphs were added. An adhesive and a micro pin was used to fasten the leaf discs to the middle of the petri-dish to prevent larvae from leaving the container.

Chemicals tested thus far include: neem extract, fenoxycarb (an insect growth regulator), fish emulsion oil, sugar used in combination with other chemicals and onion extract.

Results:
Two chemical combinations were of high efficacy in the laboratory, but their efficacy under field conditions has either been variable or untested. The effects of light and heat on the efficacy of each combination needs to be tested both in the laboratory and in the field.

Arthropod Identification and Control Service

Project Officers: D Chin, E S C Smith, H H Brown, J D Duf and K Hergstrom
Project Location: Throughout the Northern Territory

Objective:
To provide accurate advice on identification and control of agricultural and domestic arthropods to producers, government personnel, pest control operators and the general public.

Background:
The Section has provided an advisory service on entomological matters pertaining to agricultural or domestic situations for many years. Over the past few years, the demand for this service has increased dramatically as the number of horticultural producers has increased and fruit trees in suburban gardens mature.

Results:
The nature of the enquiry and the recommendation provided are recorded and enquiries entered into a data base. The information recorded may be used for future planning and allocation of research.

During the 1993-1994 period, the Branch received over 1140 enquiries.

Common enquiries from households included advice on controlling fleas and ticks on pets, control of ants in domestic situations, identifications of spiders and an assortment of insect problems on fruit trees, vegetables and ornamentals.

Most enquiries from growers were received during the late dry season and early wet season. As usual, enquiries on control of Mastotermes darwiniensis in fruit orchards were common. Other frequent enquiries included identification of beetle borers, mites, mealybugs and scales on fruit trees, vegetables and nursery plants. Seasonal swarms of chrysomelid beetles, Graptostethus and yellow-winged grasshoppers created some concern.

Alternative Toxicants for Mastotermes darwiniensis

Project Period : 1993-1995
Project Officers: D Chin, E S C Smith
Project Location: BARC

Objectives: To test the effectiveness of termiticides in laboratory cultures and in the field as alternatives to the organochlorine bait currently registered for control of Mastotermes darwiniensis.
Background:
The giant termite, *Mastotermes darwiniensis* is a serious pest of tree crops in Northern Australia. Fruit growers in the NT have a persistent problem in protecting their trees against this termite. The only chemical currently registered against this pest in horticultural situations is an organochlorine in a paste formulation. The use of this chemical is restricted to permit holders but, in line with chemical policies across Australia, the NT is attempting to test alternate pesticides to replace the organochlorines. Several candidate chemicals have been proven to be effective on ants and other termites.

Results:
Two formulations of one chemical (formulated to control cockroaches and ants) were tested against laboratory cultures of *Mastotermes darwiniensis*. Both were effective in killing the termites, over a five day period. One of the formulations will be tested as a bait in drums placed in fruit orchards infested with these termites.

Control of *Mastotermes darwiniensis* in Horticultural Situations

Project Period: 1993 - 1996
Project Officers: M J Neal, S Griffiths and E S C Smith
Project Location: Darwin area

Objectives:
Determine the level of concern in the horticultural community for *Mastotermes* and to attempt to assess the level of damage and financial losses due to this pest on horticultural blocks in the Top End.

Develop methods to detect *Mastotermes* in undisturbed and horticultural habitats; aggregate field colonies and test bait substrates and control agents against this species.

Background:
Current control methods against *Mastotermes* infestations are poorly developed, costly and often relatively ineffective. Although this termite is regarded as a major pest in the NT, little detailed information is available on the costs involved for damage or the level of success for applied control methods.

Method:
The level of grower concern, extent of damage and financial losses incurred on horticultural blocks was initially assessed by means of a questionnaire sent to most producers in the Top End.

Several systems were tested in the field in an attempt to improve the detection of colonies and when detected, various methods of aggregating the termites were employed.

Results:
More than 50% of growers responded to the questionnaire (of a sample in excess of 250). Some 65% considered *Mastotermes* to be a significant or major problem on their properties and the problem occurred in most years. Most growers had attempted control with the commercially available, paste-formulated termiticide and were satisfied with the treatment - only 17% responded that this registered product gave poor or nil control.

Field experiments indicated that 300 mm pine stakes embedded 200 mm into the soil were more effective at detecting the presence of termites on a property than 200 x 200 x 20 mm pine blocks placed on the soil surface. When chicken manure was added to soil surrounding the stakes, the detection rate increased. Once detected, termites could be induced to feed on corrugated cardboard inside a 20 L drum thus aggregating the pest and providing a medium on which to apply a toxicant.

Further field trials will be conducted to refine the detection and aggregation methods outlined above.
An Assessment of the Level of Palm Leaf Beetle (*Brontispa longissima*) Damage to Coconut Palms in the Darwin Area and the Re-introduction of the Biological Control Agent, *Tetrastichus brontispae*.

**Project Period:** 1993 - 1995  
**Project Officers:** D Chin and E S C Smith  
**Project Location:** Darwin area

**Objective:**  
Determine the level of damage by *Brontispa longissima* (Gestro) (Coleoptera: Chrysomelidae) in coconut palms before and after the release of the biological control agent *Tetrastichus brontispae* (Ferriere) (Hymenoptera : Eulophidae).

**Background:**  
The Darwin City Council has planted coconut palms extensively as street trees and along the foreshores throughout the Darwin area. Coconut palms are commonly planted in private gardens as they are attractive and fast growing. Commercially, coconuts are grown as a fruit crop and as an ornamental in the Top End. However, coconut palms in the Darwin area are subjected to heavy infestations of palm leaf beetles.

Palm leaf beetle is currently controlled with repeated spray applications of carbaryl applied to the unopened fronds. On very tall coconut palms, the new frond is too high to reach and is therefore difficult to spray. Chemical spraying will not eradicate the pest and continual insecticide application is necessary for good control. The use of chemical spraying is expensive, time consuming and harmful to both the environment and the operator.

**Results:**  
Selected sites of coconut palms along the Darwin foreshores were monitored over a 12 month period (prior to the introduction of *Tetrastichus brontispae*). A total of 8 sites were selected and 12 palms at each site were monitored at intervals of 6 weeks.

The infestation rate of palm leaf beetle larvae in coconut fronds fluctuated according to weather conditions. In the wet season the infestation rate was low, from 1-20%, but increased to 20-40% towards the middle of the dry season. The most severe damage occurred at the end of the dry season when new palm fronds had an infestation rate of 40-60%.

The parasitoid *Tetrastichus brontispae* will be re-introduced to Australia and released in the NT within the next few months.

**Arthropod Reference Collection**

**Project Period:** 1970 - 1999  
**Project Officers:** D Chin, E S C Smith, H H Brown and J Duff  
**Project Location:** BARC

**Objective:**  
To develop, curate and maintain a reference collection of economically important arthropods of the various NT agricultural industries and to develop and maintain a suitable, retrievable data base of all specimens held in the collection.

**Background:**  
The insect reference collection was initiated in 1970 and rapidly became the main Insect Reference Collection in the NT. Over the years the collection expanded to include economically important arthropods from agricultural and domestic situations as well as general collections. In 1992, the majority of the non-economic insect specimens were donated to the NT Museum.
Results:
During 1993/94 the Branch forwarded 137 specimens for species confirmation or identification. Most specimens were of economic significance.

All of the remaining specimens have been re-sorted. Details of the complete spirit collection and a small proportion of the dry pinned collection have been entered on a data base.
LAND RESOURCE MANAGEMENT DIVISION

This Division is concerned with the permanent sustainability of the land resource. Much of its concern is directed towards the education of land users towards the adoption of practices which will preserve land and water, prevent degradation and rehabilitate resources that have suffered degeneration from prior practices. The Division incorporates the Weeds Branch since weeds play a major part in the degradation of land and waterways. The generality of the Division is reported in the Annual Report and only the operations of Weeds Branch are reported here.

WEEDS BRANCH

The Weeds Branch pro-actively protects pastoral, agricultural, Aboriginal, national park and metropolitan areas from the invasion of foreign plants, by provision of technical advice, strategic control programs and specialised services.

The strategy is to eradicate selected weeds, apply control to weeds which cannot be eradicated, prevent entry of weeds to the Northern Territory and to educate and assist clients in weed control.

♦ ♦ ♦ Survey and Control of Noxious Weeds in the Darwin Region

**Project Period:** On-going
**Project Officers:** G Schultz, O Sutter, H Stapelton, G Hore, A Randall
**Project Location:** Darwin Region

**Objective:**
To assist landholders in controlling declared noxious weeds. To carry out control in key areas and continually monitor the incidence, spread and status of all weeds in the region.

**Background:**
Weeds Branch has the responsibility to oversee noxious weed control operations for the Northern Territory Government. This program commenced in the 1960s and is on-going. Noxious weeds are classified into three classes: Class A, to be eradicated, Class B, to be controlled and Class C, introduction to be prevented.

**Progress Report:**
The control of mimosa (*Mimosa pigra*) continues to use most of the available resources in the Darwin region. After a reduced program in 1991-92 on an infestation at Oenpelli, control is now on target with the residual 5000 ha being treated with tebuthiuron and fluroxypyr.

Revegetation of the area is of increasing importance as the mimosa infestation is controlled. The floodplains are recovering under native vegetation and an introduced species (para grass) which was already present in the area. To assist in this recovery a program of harvesting and planting of the native wild rice (*Oryza rufipogon*) and hymenachne (*Hymenachne acutigluma*) has commenced.

A new project has started to control mimosa along Sampan Creek on the Mary River system. This area is a popular fishing area for both locals and interstate visitors. A five year program is aimed at removing mimosa from the area and stabilising the banks with alternative species.

Salvinia (*Salvinia molesta*) infests billabongs in Western Arnhem Land after spreading from Kakadu National Park in the 1991 wet season.

Mission grass (*Pennisetum polystachion*) continues to spread in the Darwin rural area.

Roadside weed control is now showing the results of several seasons’ work. Major highways have a reduced
incidence of weeds and these are being pushed further back from the verge. Other arterial roads are now being targeted as time allows. The major broadleaf weeds spinyhead sida (*Sida acuta*), khaki weed (*Alternanthera pungens*), Sickle pod (*Senna obtusifolia*) and hyptis (*Hyptis suaveolens*) were treated between January and late February; the grasses grader grass (*Themeda quadrivalvis*) and mission grass were treated from then until mid March when they flower. Increasing amounts of gamba grass (*Andropogon gayanus*) also required spraying. This species is proving difficult to control.

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**Ecology and Management of Gamba grass**

**Project Period:** 1992 - 94  
**Project Officer:** P Barrow  
**Project Location:** Darwin - Jabiru Region

**Objectives:**  
The objectives of this study are to investigate chemical and mechanical methods of control of gamba grass, to survey and map the distribution of the species in the Top End, and to provide baseline ecological data on which to base a management strategy. The work is being undertaken throughout the range of the species in the Top End, but is concentrated between the Adelaide and South Alligator River districts. A large herbicide trial, involving a range of chemicals and treatments, was carried out at Coastal Plains Research Station.

**Background:**  
Gamba grass, *Andropogon gayanus*, is a large, clumping, perennial species, growing to about four metres. It is recognised as a useful pasture species in the Top End, and is well established on many pastoral properties. It is now observed to be spreading unaided into non-pastoral areas, and concern by non-pastoral land managers, particularly the Australian National Parks and Wildlife Service, has led to this study.

Gamba grass produces a much higher fuel load than the native annual *Sorghum* spp., and cures later in the dry season. Fears have been expressed that these characteristics will cause alterations to the prevailing fire regime. This would mean hotter fires, later in the dry season, causing both ecological damage and increased property losses.

**Progress report:**

Results indicate that gamba grass has the potential to invade most, if not all of the savanna types, and some monsoon rainforest types in the Top End. Distribution is largely restricted to disturbed areas, however. While most infestations occur along roadsides, wetter areas such as creeklines and floodplain fringes are also susceptible to invasion. Seed production and viability are high, and the major dispersal mechanism appears to be human activity. Glyphosate was the most effective herbicide tested, but timing of application may be critical.

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**Eradication of Parthenium Weed (*Parthenium hysterophorus*)**

**Project Period:** 1.1.77 - 31.12.95  
**Project Officers:** J Pitt, R Smith, S Newbould, M Crothers, L Johns  
**Project Location:** Elsey Creek

**Objective:**

To eradicate the only known infestation of parthenium weed (*Parthenium hysterophorus*) in the Northern Territory.

**Background:**

Following its discovery in August 1977, a combination of aerial and ground-based herbicide application
methods were used to control this isolated infestation of parthenium. Over a period of years the infestation has been reduced to a level where only ground-based control is necessary.

Progress Report:
Surveys of Elsey Creek resulted in the discovery of six immature parthenium plants obscured by dense vegetation. Increasing density of vegetation in the area may prevent eradication confirmation in 1995.

Survey and Control of Noxious Weeds in the Katherine Region

Project Period: 1.1.91 - 31.12.95
Project Officers: J Pitt, R Smith, S Newbould, M Crothers and L Johns
Project Location: Katherine Region

Objectives:
To prevent the introduction of, spread of, and where possible eradicate, Class A, B and C noxious weeds; to monitor and map infestations of noxious weeds in the Katherine Region; to maintain control of strategic infestations and to assist landholders with weed control.

Background:
This program includes weed control on Crown Land and in key locations where effective management of weeds are crucial. It also includes the interpretation of aerial photography, aerial and ground-based surveys, release and monitoring of biological control agents, and enforcement activities. Funding assistance by the Department of Transport and Works from 1988 has enabled an expansion of roadside weed control. Other funding assistance was received in 1994 from the Ngaringman Association to survey and control weeds on Aboriginal communities in the western VRD, and from the Department of Lands and Housing for weed control on Crown Land in the Katherine Township.

Progress Report:
Most noxious weed outbreaks were visited at least once this year with appropriate control or monitoring of outbreaks carried out.

The section maintained control of the Class A noxious weeds chinee apple (Zizyphus mauritiana), devil's claw (Martynia annua), mimosa (Mimosa pigra) and prickly acacia (Acacia nilotica).

Aerial spraying of devil's claw continued at Willeroo this year, however, the infestation is expanding. Approximately 550 ha were treated this year compared to 448 ha in 1993 and 150 ha in 1992. An aerial survey of Stray Creek was of benefit in the discovery and treatment of isolated mimosa plants. Ground control of lion's tail (Leonotis nepetifolia) was undertaken at Yarralin. This infestation continues to expand and now threatens the entire Victoria River system.

Biological control of Sida spp. with Calligrapha pantherina has proved unsuccessful in the Katherine Region. Releases of the stem borer Eutisobothris sp. to an irrigated Sida patch at KRS are being monitored. Monitoring of noogoora burr (Xanthium occidentale) infestations throughout the Katherine Region have failed to recover any significant numbers of the biological control agent Epiblema strenuana. Noogoora burr continues to be introduced to the Northern Territory on contaminated cattle from Queensland, and further spread of this species is likely. Roadside weeds including hyptis (Hyptis suaveolens), caltrop (Tribulus terrestris), mission grass (Pennisetum polystachion), grader grass (Themeda quadrivalvis) and Sida spp. continue to be controlled under the externally-funded roadside weed control program.
Control of Bellyache Bush (*Jatropha gossypifolia*)

**Project Period:** 1981-1995  
**Project Officer:** J Pitt  
**Project Location:** Willeroo Station

**Objectives:**  
To develop recommendations for chemical control of bellyache bush; to refine herbicide application rates and methods; and to study biological aspects of importance in control of bellyache bush.

**Background:**  
Bellyache bush (*Jatropha gossypifolia*) is a noxious weed with a wide distribution in the Northern Territory. Herbicide efficacy trials have been conducted on this species since 1981, however, due to ecological aspects, the introduction of new herbicides, changes to the herbicide registration requirements, and the expansion of one large infestation at Willeroo Station, research activities are continuing.

In an effort to establish an integrated control strategy for the species, research has been directed at determining the rate of spread of bellyache bush, its seed longevity and its susceptibility to a range of soil and foliar applied herbicides.

A seed longevity trial has revealed that bellyache bush seed buried at 0.0, 1.0, 5.0 and 10.0 cm in two soil types has a half life of 4 months and longevity of about 4 years. This indicates that chemical control of bellyache bush may be cost-effective providing that follow-up control is undertaken.

**Progress Report:**  
To complement existing research, a trial is proposed to determine the effects of various burning strategies for controlling bellyache bush and to monitor off-target species for significant changes.

Four treatments are proposed and include:  
- No fire (control);  
- Biennial burn;  
- Annual burn (September);  
- Annual burn (November).

The various burning strategies will compare the effects of burning temperature through differences in seasonal humidity and dry-matter accumulation against seed survival.

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Eradication of Class A Noxious Weeds in the Southern Region

**Project Period:** 1988 - 1995  
**Project Officers:** M Fuller, A Gracie, J McMahon  
**Project Location:**  
- Banka Banka Station (Longspine thornapple)  
- Eastern Barkly Tableland (Prickly acacia)  
- Alice Springs (Paterson’s curse)  
- McArthur River (Devil’s claw)

**Objective:**  
To eradicate the above weeds from the Southern Region.

**Background:**  
Longspine thornapple (*Datura ferox*) was first recorded at Banka Banka Station in 1988. Control has been carried out since 1988.
Prickly acacia (*Acacia nilotica*) was first recorded on Avon Downs in 1982. Control has been carried out over recent years including control along the Georgina River in Queensland with Queensland Authorities.

Paterson’s curse (*Echium plantagineum*) was first recorded in the Alice Springs region in 1979. Surveillance of all previously infested areas will continue and any outbreaks will be controlled.

**Progress Report:**
Juvenile prickly acacia plants were found on Rockhampton Downs and Alexandria Station. All plants were destroyed.

Devil’s claw (*Martynia annua*) plants on McArthur River Station were destroyed.

A large outbreak of Paterson’s curse at Kulgera trucking yards and several smaller infestations around Alice Springs town were controlled.

All other Class A Weed sites were surveyed but no plants were found. Survey will continue to ensure germinating plants are controlled before seeding to ensure eradication is complete.

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**Survey and Control Of Noxious Weeds In the Southern Region**

**Project Period:** 1/1/92 - 31/12/95

**Project Officers:** M Fuller, A Gracie, J McMahon

**Project Location:** Southern Region.

**Objective:**
To prevent the introduction of, spread of and, where possible, eradicate Class A, B and C noxious weeds; to monitor and map infestations of noxious weeds in the Southern Region, to maintain control of strategic infestations and to assist landholders with weed control.

**Background:**
This program includes weed control on Crown Land and in key locations where effective management of weeds are crucial. It includes the interpretation of aerial photography, aerial and ground-based surveys, release and monitoring of biological control agents, and enforcement activities. Funding assistance from the Department of Transport and Works has allowed weed control along major and minor arterial roads to continue.

The Aputula Aboriginal Community and Tjuwanpa Outstation Resource Centre received external funding to assist in control of Athel pine (*Tamarix aphyl/a*). Yuendumu community has received funding to assist in control of parkinsonia (*Parkinsonia aculeata*) and rubberbush (*Calotropis procera*).

**Progress Report:**
Athel pine has been eradicated from the Finke River, from the headwaters to the Stuart Highway. Control is continuing at several locations downstream.

All noxious weeds on Government stock routes and Crown Land are under control. Eradication is feasible in many areas.

*Mimosestes ulkei*, a biological control agent of parkinsonia, was released on Banka Banka Station.

Major control efforts continued on parkinsonia, rubberbush and Noogoora burr (*Xanthium occidentale*).
Chemical Control of Athel Pine (*Tamarix aphylla*)

**Project Period:** March 1992 - March 1994
**Project Officers:** M Fuller, F Sheil
**Project Location:** New Crown Station

**Objective:**
To determine minimum rates of chemicals required to control Athel pine by stem injection and basal bark treatment.

**Background:**
Athel pine, an introduced tree, is causing environmental damage along the Finke and Ross Rivers of Central Australia and is capable of invading other rivers. Unless controlled this tree has the potential to destroy the ecosystem of Central Australian rivers.

**Progress Report:**
The trial has been completed but results have not yet been analysed.

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Chemical Control of Rubberbush (*Calotropis procera*)

**Project Period:** 1992 - 1994
**Project Officers:** D Gracie, J McMahon
**Project Location:** Powell Creek Station, Elliot

**Objective:**
To develop recommendations for the chemical control of rubberbush in dry and wet seasons.

**Background:**
Rubberbush is declared noxious in the Southern region of the Northern Territory. It has proved difficult to control and research is required to test new herbicides and determine their efficacy.

The chemicals trialed were metsulfuron methyl 600 g/L, fluroxypyr with picloram and diesel, triclopyr 600 g/L and imazapyr. Imazapyr, metsulfuron methyl and triclopyr were applied with and without 0.2% pulse penetrant.

Controls with no product and with 0.2% pulse penetrant were applied.

This trial supplements the wet season control trial on rubberbush at Powell Creek Station.

Results of the wet season herbicide trial of rubberbush conducted on Powell Creek Station were analysed.

100% kills were achieved using:

Overall spray -
1:400 Arsenal® and water + 0.2% pulse
1:300 Arsenal® and water + 0.2% pulse
1:200 Arsenal® and water; no water
1:200 Arsenal® and water + 0.2% pulse

Basal Bark Treatment -
1:30 Garlon® and diesel

However there was no significant difference between the means of the five treatments above and a further seven treatments (12 in all).

Other Treatments -
1:300 Arsenal® and water; no pulse (overall spray)
15gms Brushoff® and water + 0.2% pulse (overall spray)
30gms Brushoff® and water + 0.2% pulse (overall spray)
1:400 Arsenal® and water; no pulse (overall spray)
10gms Brushoff and water + 0.2% pulse (overall spray)
1:30 Starane®/Piloram® mix in diesel (basal bark)
1:30 Arsenal® in diesel (basal bark)

The dry season trial, applied in January 1994, is incomplete.

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**Biological Control of Mimosa and Hyptis**

**Project Period:** 1979 to 1996

**Project Officers:** C Wilson, G Flanagan, M Paskins, D van Rangelrooy, S Gall, P Barrow with CSIRO
Division of Entomology

**Project Location:** Darwin Region

**Objective:**
Efficiently breed and release host-specific natural enemies of these weeds, monitor their establishment and spread, and study their impact on the weed populations.

**Background:**
Mimosa (*Mimosa pigra*) is one of Australia's most important environmental weeds (Humphries *et al.* 1991), and is a major hindrance to pastoral activities, tourism and public amenity in the monsoonal regions of the Northern Territory. Hyptis (*Hyptis suaveolens*) is probably the most widespread weed in northern Australia. Both species are native to the American tropics.

An investigation into the biological control of these weeds commenced in 1979 involving both the DPIF and CSIRO. From 1984, the Australian Centre for International Agricultural Research (ACIAR) provided funding for the control of mimosa in Thailand, which enabled further exploration for potential biological control agents, and most recently additional funding has been received from the Commonwealth.

During 1980-81, the search for natural enemies of mimosa and hyptis was centred on Brazil, with brief sorties to Mexico, southern USA and Venezuela (Harley *et al.* 1985). Since 1984 the search has concentrated on Mexico, with visits to Costa Rica, Honduras and Venezuela.

**Progress Report:**
To date, seven species of insects and one fungal pathogen, imported from Mexico and Brazil, have been released in the Northern Territory as biological control agents of mimosa. Six species of insects are known to have become at least locally established, while it is too early to determine the fate of the two most recently released agents.

Two species of seed beetle, *Acanthoscelides puniceus* and *A. quadridentatus*, are widespread but destroy less than 1% of the seed output (Wilson and Flanagan 1991).

The leaf beetle, *Chlamisus mimosae*, has for many years been considered scarce and restricted to the vicinity of release sites near the Finniss River. It has recently spread to mimosa throughout the Finniss River district, infesting over 90% of stems in some places. Redistribution of these beetles to areas on the Adelaide River was carried out, but there has been no evidence of establishment there.

The tip-boring moth, *Neurostrota gunniella*, is established throughout the range of mimosa in the Northern Territory. Its build-up in density and spread from release sites has been spectacular. It has spread at least 200 km from the nearest release site and attacked nearly 100% of mimosa tips. Preliminary studies indicate that it significantly reduces seed production, and that it concentrates at the edge of mimosa thickets, which is where most seed production occurs.

The stem-boring moth, *Carmenta mimosae*, is well established and has spread at least 4 km from release sites on
the Finniss River, and is persisting well at several CSIRO experimental plots on the Adelaide River plains.

The bud-feeding weevil, *Coelocephalapion aculeatum*, appears to be established and spreading at sites on the Adelaide and Finniss River floodplains, while the more recently introduced *C. pigrae* has been released at one site on each of the Adelaide and Finniss Rivers.

The fungal pathogen, *Phloeospora mimosae-pigrae*, has been released at sites on the Adelaide and Finniss River floodplains but, as it is mainly active in the wet season, it is too early to tell whether or not the releases have been successful.

Testing of a second mimosa pathogen, *Diabole cubensis*, has commenced at the International Institute of Biological Control (IIBC), UK, and will probably take about two years to complete. Preliminary biology studies have begun on weevils that feed on immature seed pods (*Chalcodermus sp.* and *Sibinia sp.*), and on flea-beetles (*Altica spp.*) that feed on roots and leaves.

A promising pathogen, *Puccinia hyptidis*, has been discovered attacking hyptis in Mexico. If alternative funding is not obtained, it is unlikely that the pathogen will ever be tested.


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### Biological Control of Sida

**Project Period:** 1984 to 1996  
**Project Officers:** G Flanagan, L Hills  
**Project Location:** Darwin and Katherine regions

**Objective:**
To efficiently breed and release host-specific natural enemies of the weedy sida species, to monitor their establishment and spread, and to study their impact on the weed populations.

**Background:**
Spinyhead sida (*Sida acuta*) is a perennial weed of improved pastures, disturbed areas and roadsides in northern Australia. It is a small, erect shrub with a woody, fibrous stem and a deep taproot, usually growing to about 1 m in height but exceeding 2 m in favourable circumstances. It can dominate areas that are heavily grazed. Flannel weed (*Sida cordifolia*), spiny sida (*Sida spinosa*) and Paddy's lucerne (*Sida rhombifolia*) are other similar species of sida that can cause problems to landholders.

These sidas are all native to tropical America and have been in Australia for at least 100 years. They are widespread in the monsoonal regions of the Northern Territory.

In 1984 a biological control program for sidas was commenced with the establishment of an exploratory station in Mexico funded jointly by the DPIF and the CSIRO Division of Entomology (Wilson and Flanagan 1990). The aim was to search the Americas for damaging natural enemies of the sidas and to introduce into Australia those that passed stringent host-specificity tests.

**Progress Report:**
The sida leaf beetle *calligrapha* (*Calligrapha pantherina*) was first released onto spinyhead sida in September 1989 at Finniss River Station, and subsequently at several hundred sites across the Northern Territory, either directly from the laboratory cultures or from field collections. Population increase in the field has at times been dramatic, but unaided spread away from the points of release has been slow. With each successive wet season, the beetle has become more widespread in the Darwin region, has persisted at more sites over the dry season and returned to more sites with the onset of the rains.

A field study, using insecticides to maintain some plants insect-free, showed that calligrapha beetles can reduce seed production in spinyhead sida by over 90%, leading to a reduction in plant density in one year of more than one third (Lonsdale *et al.* in press). Widespread field observations have confirmed the results of the study.
A calligrapha management strategy has been devised for landholders to help the beetles survive the dry season and hence be able to control sida infestations as they germinate following the first rains (Hills 1993).

The sida stem-galling weevil *Eutinobothris* sp. has been released at a number of sites in the Darwin and Katherine regions. It is too early to claim establishment, but the situation looks promising.

A search will commence shortly in tropical America for natural enemies of flannel weed.

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**Biological Control of Parkinsonia**

**Project Period**: 1982-1994  
**Project Officers**: C Wilson, G Flanagan, P Barrow, D van Rangelrooy  
**Project Location**: Darwin, Katherine and Tennant Creek districts

**Objective**: Efficiently breed and release host-specific natural enemies of parkinsonia, monitor their establishment and spread, and study their impact on populations of the weed.

**Background**: *Parkinsonia* (*Parkinsonia aculeata*) is a woody, thorny shrub or small tree that can form dense thickets, making areas of land inaccessible for both people and animals. It is native to southern USA, Mexico and Central America, but has become one of the most troublesome weeds in the Northern Territory, especially on the Barkly Tableland.

In 1982 DPIF, the WA Department of Agriculture and the Queensland Department of Lands entered into a joint biological control program against parkinsonia. As a result, an entomologist was despatched to search for natural enemies of the weed in its native range (Wilson and Miller 1987). The aim of the project is to effect lasting control of parkinsonia in Australia by introducing host-specific natural enemies.

**Progress Report**:
The tiny cryptic mirid bug, *Rhinacloa callicrates*, was first released in the Northern Territory at Alroy Downs Station on the Barkly Tableland in December 1989, and has since been released at four other widely-spaced sites. Establishment has not been confirmed at any site.

The parkinsonia seed beetle, *Mimosestes ulkei*, has been released at several sites on the Barkly Tablelands. Due to a lack of resources, releases have been suspended and none of the release sites have been checked to see whether or not establishment has occurred.

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**Biological Control of Siam Weed in Indonesia and the Philippines**

**Project Period**: 1993-1995  
**Project Officer**: C Wilson  
**Project Location**: Eastern Indonesia

**Objective**: To advise and assist Indonesian scientists and technicians in efficiently breeding and releasing host-specific natural enemies of Siam weed and monitoring their establishment and spread.

**Background**: Siam weed (*Chromolaena odorata*) is native to tropical America and the West Indies, but has become one of the most important weeds in the wet tropics of Africa and Asia. It is a fast-growing perennial shrub, producing abundant wind-blown seeds and forming dense thickets in pastures, plantations, roadsides and woodlands,
choking out all other vegetation and presenting a serious fire hazard. During the last 50 years Siam weed has been spreading inexorably through Asia towards Australia. It is now established in Timor and Irian Jaya. The Top End of the Northern Territory, Cape York Peninsula and coastal Queensland are under imminent threat of invasion by Siam weed, either from wind-blown seeds or accidental introduction on clothing or mining equipment.

The Commonwealth Institute of Biological Control (CIBC) searched the West Indies for natural enemies of Siam weed from 1966 to 1972 (Cruttwell McFadyen 1989). A leaf-feeding moth, pareuchetes (Pareuchetes pseudoinsulata), was subsequently released in a number of countries, giving successful control in Guam and the Marianas, but variable results elsewhere (Julien 1992). The Australian Centre for International Agricultural Research (ACIAR) has financed a 3-year biological control project involving the Queensland Department of Lands and the DPIF Weeds Branch, beginning in January 1993.

Progress Report:
The project collaborator in the Weeds Branch has discussed the project with two Timorese scientists based at Nusa Cendana University in Kupang, and they have agreed to carry out the rearing and releasing of biological control agents. The facilities available in Timor have been inspected and advice given on best use of the extremely limited resources available.

Quarantine testing of the host-specificity of the potential biological control agents is carried out at the International Oil Palm Research Institute at Marihat in northern Sumatra. This facility was visited, and the biology of the first of the agents, the pareuchetes moth, was studied. A culture of several hundred pupae was carried to Timor to begin a culture there. A portion of the Darwin budget was transferred to Timor to enable one of the Timorese collaborators to visit Marihat to study the rearing of the moth directly, and to pay for rearing cages, transport to release sites and a nursery assistant in Timor.

Quarantine testing of a stem-galling fly, Procecidochares sp., is almost complete in Marihat.

- - - Assisting Clients with Weed Control

**Project Period:** On-going

**Project Officers:** All Weeds Staff

**Project Location:** All Regions

**Objectives:**
Educate and assist clients in weed control and provide incentives for clients to conduct weed control; prevent entry of all weed species into the NT, including those already present; reduce the impact of noxious weeds on industries and the environment.

**Methods:**
Hold short courses for client groups; promote the safe, effective and efficient use of herbicides and other control methods; promote the control of noxious weeds through the herbicide subsidy scheme, the spray unit loan scheme and aerial spraying subsidies; coordinate, develop and assist landholders with weed control activities; identify weed species and provide advice on control methods, equipment and herbicides.

**Progress Report:**
This year Weed Control Workshops were held for Open College students and Park Rangers and a Weed Identification Workshop was held for Katherine District farmers and Katherine Town Council personnel. Displays were prepared for the Katherine and Berrimah Farm Open Days, March Landcare Month, NT Bushfires Council and the Katherine Show. Annual Weeds Calendars, posters and letters were distributed to pastoral properties, roadhouses, Aboriginal communities, and schools. Many enquiries were answered regarding noxious and nuisance plants.

Articles appeared in the NT press on mimosa, Paterson's curse, Athel pine, parthenium weed and Landcare month.
The National A.B.C. Television program, Landline, did a story on Athel pine control in the Finke River. Radio interviews on woody weed control in the USA, Noogoora burr, Devil's claw, parkinsonia on the Barkly Tablelands, the Athel pine control program, the rubber vine buffer zone proposal, and the control of Mexican poppy and Paterson's curse were broadcast on the ABC "Country Hour". Radio 'talk-back' commentaries were given by staff during Landcare Month on gardening programs.

The mimosa aerial spraying and herbicide subsidy schemes continue to be well supported. Several properties have requested a review of the scheme as they have reduced their mimosa infestations to a level where ground control is more economic and the schemes do not reflect this need.
PROGRAM 1 SUSTAINABLE PASTORAL PRODUCTION

Objective:
This series of trial looks at various ways of improving production from rangeland grazing and maintaining the rangeland in a stable state. This work extends over a number of seasons and the avenues being explored are the use of introduced species of legume to add quality to the pasture, the use of fire to renovate the rangeland and prevent woody weed invasion, the effect of stocking rate and the use of introduced top feed species.

Evaluation of Various Sown Legumes and Grasses. 1: Improved Pasture Demonstrations

Project period: 1988 - 1994
Project officer: Reg Andison
Project location: Eva Valley, Bloodwood Downs, Mataranka

Objective:
Expose interested producers to various improved pasture species, sown on various soil types and in various rainfall areas, for dryland establishment and to develop recommendations for pasture improvement in intensive use areas. Test new pasture species, in conjunction with other State Departments, as they become available.

Background:
The major problem with existing native pasture in Northern Australia is its low nutritive value for most of the year. The value of native pasture can be improved by wet and dry season supplementation and regular, planned use of fire. Pasture improvement by introduction of legumes and superior grasses is another method of improving the nutritive value.

The principal uses of improved pasture are either as areas of special nutrition for key groups such as weaners, heifers, sale steers or poor cows, or to increase the carrying capacity on properties where area has become limiting.

This project has exposed pastoralists to improved pasture species suitable for improving small intensive use areas such as holding paddocks as well as species suitable for improving larger areas with low inputs.

Results:
Species planted included a number of buffel grasses, secia and amiga stylo, rhodes grass, cavalcade, wynn cassia and silk sorghum.

Germination at all sites was good following a well spread wet season. However subsequent performance was variable across the three sites. At the Eva Valley site, performance following germination was very poor. This was due to the poor soil at the site. The buffel grasses established at 19.7 and 15.4 plants/m² on the fertilised and unfertilised plots respectively. The stylos (Seca and Amiga) established at 2.5 and 0.2 plants/m² on fertilised and unfertilised plots. Plants did not get much above 10 cm in height and set very little seed.

The site at Mataranka performed best of the three. All species germinated and produced reasonable yields. Cavalcade performed best with 4.5 t/ha and the buffel grasses produced 1.5 t/ha.

The Bloodwood site was disappointing because access problems delayed planting until mid January. All species germinated and established at this site but subsequent performance was limited by the late planting date. Glenn joint vetch and Biloela buffel grass established the best.

Discussion:
These demonstration sites have been running for five years. Indications, following four difficult pasture establishment years, are:

If land is not limiting, the best method of improving animal production is by looking after the native pasture and spelling it regularly.
Introduced grasses should not be considered unless time and energy can be spent on establishment and management, including strict stock control.

Legumes such as Seca, Verano and now Amiga seem well suited to pasture improvement in the extensive pastoral areas of the Katherine Region.

Don’t waste time and energy on poor country when there is still good country to be improved.

Plant improved pastures as early in the wet season as possible to ensure good growth in the first wet season.


Project Officer : Reg Andison
Project Location: Katherine Research Station and ‘Stillwater’ Daly Waters

Objective:
To accelerate the release of new, well adapted legume cultivars (particularly from Aeschynomene and Chamaecrista (formerly Cassia)) to complement and back-up currently used legume cultivars (particularly for the Stylosanthes species).

Background:
There are two main benefits. 'Back-up legumes' offer insurance against the potential threat of stylo cultivars collapsing from disease. This would greatly reduce animal production and would destroy cattle industry confidence in sown pasture development. 'Back-up legumes' will also provide new legumes to expand the area sown to pastures (new niches and situations) and to increase cattle production by providing high quality forage to complement stylos.

A large and increasing area of Queensland is planted to stylo based pastures which are providing increased animal growth (average 30 to 40 kg/head/year). Seca seed production is 150 t/year, Verano 80 t, Glenn joint vetch 40 t and Wynn roundleaf cassia 30 t. Currently Seca and Verano dominate the sown pasture legume scene in the under 1000 mm rainfall zone. The fungal disease anthracnose is a potential threat to all stylo pastures.

Glenn joint vetch is widely sown in the over 1000 mm rainfall zone and producers high quality forage because of good nitrogen fixation. Other Aeschynomene species, with similar characteristics and quality, have the potential to adapt to the 700-1000 mm zone. The new back-up legumes should generate increased animal production as well as providing alternatives and back-up to the stylos.

Results:
Assessment of the 1992/93 planting was carried out in the early wet season. At the Katherine site, the best performance by far was from Aeschynomene brasiliana CPI 92519 and Aeschynomene brasiliana CPI 93592. These were followed closely by the stylos, Verano and Amiga and Seca and Siran. In fact Aeschynomene brasiliana CPI 93592 has performed so well in some Queensland plots that it has been eradicated because of concerns about weediness. Consequently it will be sprayed out of the NT DPIF plots this season. The Daly Waters site was replanted due to lack of establishment the previous year. Prior to replanting, the only introduced species present were Seca Stylo and Verano Stylo.

The 1993/94 planting comprised mostly of Desmanthus species, with some Cassia species. At the Katherine site Cassia rotundifolia CPI 93094 and Cassia rotundifolia cv Wynn were best performed. Desmanthus virgatus cv Marc and Desmanthus virgatus CPI 30205 performed best of the Desmanthus. At the Daly Waters site Aeschynomene falcata cv Bargoo and Cassia rotundifolia cv Wynn were the best performed, with Desmanthus virgatus BBAC10 close behind.
Evaluation of the Effects of Three Burning Strategies

**Project Period:** 1989 - 1995
**Project Officer:** Reg Andison
**Project Location:** Kidman Springs

**Objective:**
Compare the effects of burning strategies on shrub density on black soil at Victoria River Research Station and compare the effects of burning strategies on pasture yield and composition on black soil. The specific objective of this trial is to examine the effects of biennial and triennial burning on shrub numbers and pasture condition. For this to work we must maintain an adequate fuel load.

**Background:**
At the 1989 Tripartite conference hosted by the DPIF Katherine, concern was voiced over the apparent encroachment of shrubs onto previously clear black soil plains. It should be noted that shrubs have little effect in reducing sheet erosion, but they may reduce pasture production.

The major reason for the shrub encroachment was suggested as being due to lack of the use of the cheapest pasture management tool available - fire. Suggested reasons for the reduction in fire use were: drier years, higher stocking rates, supplementary feeding and the increased foraging ability of the Brahman breed, all contributing to a reduced grass fuel load at the end of the dry season.

**Results:**
With two burns of the biennial treatment (1991 and 1993) and one burn of the triennial treatment (1992), no real trends have developed. The only response so far is the effect of the previous wet season on fire intensity. Both fires in the biennial treatment (1991 and 1993) were lit following wet seasons which produced very good pasture growth. This provided a large fuel load and a more intense fire.

The very intense fire in 1991 produced a mass germination of *Acacia bidwillii* seedlings. This was not totally unexpected as prolific seedling growth is likely to follow a hot fire. One method of controlling acacias is to burn an area several times in succession so that the seed source becomes exhausted. At the time of the 1993 fire there were very few *Acacia bidwillii* seedlings present. Suggestions are that the very poor wet season in 1991/92 contributed to the demise of this very young population.

Observations indicate that rosewood (*Terminalia volucris*) is very susceptible to fire but regrows quickly.

**Discussion:**
Indications so far are:
- the burning program must be flexible i.e. burn when there is adequate fuel.
- once a burning program is initiated it should be maintained. A once off fire may cause woody weed problems to become worse (eg. *Acacia bidwillii*).

A Long Term Demonstration and Evaluation of the Impact of Stocking Rate on Annual Weaner Turn-off Per Square Kilometre of Native Pasture

**Project Period:** 1993-1997
**Project Officer:** Neil MacDonald
**Project Location:** Mt. Sanford Station

**Objective:**
To demonstrate that moderate stocking rates are an essential part of sustainable cattle production off semi-arid native pasture, and can lead to higher profitability in the medium and long term.
Background:
Of all management decisions facing cattle producers, selection of a suitable stocking rate is perhaps the most important. It is well accepted that overstocking leads to pasture degradation but management for long term sustainability is often considered to be incompatible with short term profit. Evidence that individual animal productivity in the region is constrained by overstocking came from fertility studies on five stations conducted between 1987-1992.

This project is a large scale demonstration with a simple design, reflecting the project's aim of changing attitudes rather than drawing up precise guidelines. There are six treatments: four paddocks receiving supplementation and stocked at 5, 7.5, 10 and 15 head/sq km, and two not supplemented stocked at 5 and 7.5 head/sq km. Each treatment is stocked with 54 breeders, 2 bulls, 10 steers. Two musters per year are held, in May and October. Calves are weaned at 120 kg and weaners leave the project. Pasture monitoring is carried out at the beginning and end of each dry season. Over the period of the project, the treatments will be compared in terms of weaner production per head and per sq km, annual steer growth and pasture changes.

This project occupies 65 sq km of Mt Sanford Station. New infrastructure installed totalled 55 km of new fencing, 2 tanks, 8 troughs and 25 km of water pipeline. The project is part funded by the National Landcare Program and the Meat Research Corporation.

Results:
The site survey started in April 1993, and infrastructure was completed and the trial stocked in August 1993. Musters were conducted in October 1993 and May 1994. Pasture monitoring was conducted in November 1993 and April 1994.

Rainfall of 450 mm was measured on the site over the 1993-94 wet season. This is about the long term average, but the early start and even spacing of the rain brought excellent pasture conditions.

Steer growth between August and May averaged 152 kg in the supplemented paddocks and 141 kg in the unsupplemented ones. There were no differences attributable to stocking rate. Overall breeder mortality was 2%.

Two very successful field days were held on the site. The project opening in August 1993 attracted about 60 people and considerable media interest. The field day in June 1994 attracted about 100, mostly interstate visitors attending the Australian Rangeland Conference.

Discussion:
Fluctuating wet seasons are always likely to complicate stocking rate decisions. Undoubtedly 1993-94 was one of the best on record and cattle would have prospered under higher stocking rates than normal. Over the life of the project, good and bad seasons should even out.

Steer growth recorded this year is very high. Breeder performance was largely a reflection of the cows' status as they entered the trial, but the large number getting into calf while still lactating foreshadows a high calving rate over the next year.

The publicity attached to this trial is probably already achieving the main aim of the trial - to draw attention to the question of sustainable stocking rates and change attitudes.

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The Establishment and Maintenance Plots of Fodder Shrubs.

Project officer: Neil MacDonald
Project location: Katherine Research Station

Objectives:
Conduct preliminary screening of native and introduced shrubs that may have value as fodder in the semi-arid
Multiply seeds of species of interest.

**Background:**
The use of high quality browse shrubs for cattle production has several potential advantages over herbaceous species, especially the maintenance of high protein levels through the dry season. Where successful, fodder trees have revolutionised intensive production systems, but there are few species that have attained that level of success. In tropical Australia there is just one - *Leucaena leucocephala*. Reliance on a single species is risky and limits the number of places where fodder tree systems can apply.

An ideal fodder shrub must establish and grow, produce substantial leaf that is palatable all year and stays within reach of livestock, withstand browsing, be long lived and withstand insect attack. The palatability question is important as that may be all that separates a successful fodder shrub from a dangerous woody weed.

This project attempts just the first stages of screening. Very few seeds of each species were obtainable. Thirty six varieties were established in the shadehouse and planted out in 1991. They were irrigated for their first two dry seasons. Notes were taken of their growth rate, growth characteristics and leafiness, with seeds being collected from the most promising.

**Results:**
None of the varieties so far tested have been considered worthy of further testing.

Two varieties of *Acacia angustissima* have been the most successful in the arboretum. However reports from Queensland have described the species as being variable in palatability and a potential weed, so no further work is advisable.

Several *Desmodium* spp. and *Codariocalyx gyroides* showed early promise but declined after two years, as did *Cajanus cajan* which was attacked by insects.

Several species, *Albizia* spp., *Sesbania grandiflora*, *Enterolobium* sp. have grown well but are much too tall for cattle to reach the leaves. While they may be useful shade trees, they are not suitable for browse shrubs.

**Discussion:**
Although this project is coming to an end, the arboretum will be maintained and be available as a site for trial planting of other species that could be useful in the Katherine Region.

**PROGRAM 2 BREEDER HERD PRODUCTIVITY**

**Objective:**
The objective of this series of trial was to identify cost effective techniques capable of increasing the number of calves weaned per breeder lifetime from 2.5 to 4.5 in the Katherine region by the year 2000.

**Overview:**
There are two components to an increase in calves weaned per breeder lifetime - an increase in weaning rate and a decrease in breeder mortality. The figure of 2.5 calves per breeder lifetime arises from the production figures of the Kidman Springs herd from 1980-1990, averaging 50% weaning and 12% breeder mortality. Other studies have demonstrated these figures to be representative of commercial herds in the region. 4.5 calves per breeder lifetime corresponds to a weaning rate of 65% and a mortality rate of 5%.

The main constraint to cattle production in the Katherine Region continues to be nutrition. Previous cattle production studies in the Katherine Region have identified and tested a number of individual management strategies in isolation - weaning, native pasture management, supplements etc.
Since 1990 the main project in this program has been the combination of successful management strategies previously researched into an integrated and cost-effective package, demonstrated as a "Best Bet Herd" (project 2.1). The results achieved over the last four years have been startling. Average mortality rate has been cut from 12% to 3%, while the average weaning rate has increased to 75%. This equates to 5.2 calves per breeder lifetime. In 1993/4 most of the Katherine Region had a favourable wet season. At Kidman Springs a weaning rate of 80% and a 2% mortality rate was recorded.

Most stations in the Katherine Region have implemented at least parts of the 'Best Bet' package. Extension remains a very important part of the program. It is planned that a portion of the 'Best Bet' herd be continued in the future, with the recommended package being regularly updated to include future research results.

One aspect of herd productivity with obvious scope for improvement is the management of replacement breeders. Two projects in this program address this - immunological control of oestrus and spike feeding of first calf heifers. The fourth project is concerned with investigating specific mineral deficiencies to improve the effectiveness of supplementation.

Strong market demand for feeder steers to be exported live to SE Asia has resulted in improved prices for young high quality turn-off, giving the industry both the incentive and the resources to institute management changes.

Planning has begun on the next stage of breeder research - What type of animal should we be trying to produce in ten year's time and what research should we begin now to prepare for that? A joint industry - research workshop in Kidman Springs in May 1994 came up with a proposal to evaluate breeds and crossbred combinations, for the ability of their progeny to meet future market specifications in terms of meat quality and performance in tropical feedlots, and for breeder survival and productivity in native pasture in the Victoria River District.

Improving heifer productivity through oestrus suppression.

**Project period:** 1991-1995  
**Project Officer:** Neil MacDonald  
**Project Location:** Katherine Research Station

**Objective:**  
To test potential immunological methods of controlling early conception in young heifers, resulting in replacement breeders with a higher mature size.

**Background:**  
Previous research in the Katherine Region identified high mortality and low calving of young breeders (until they have weaned their second calf) as a major component of low productivity in the region and suggested that improved management directed specifically at this class of stock would stand a good chance of a cost-effective response.

A major aspect of the management problem of replacement breeders is that the early sexual maturity of crossbred heifers combined with the slow annual growth rates allows some heifers to get into calf as low as 240 kg liveweight. At that size, the heifer loses weight throughout her lactation. Most then fail to conceive the following year, but the subsequent mortality of those that do is high.

The inadequacy of fencing as a means of segregating heifers from bulls has been clearly demonstrated in the large paddocks of this region. Computer modelling suggested that a treatment delaying the onset of puberty for one year, in these underweight heifers, would be profitable. This led to interest in immunological ways of controlling oestrus. Although many possible approaches exist, the only readily available one is Vaxstrate®, an anti-reproductive vaccine, registered for immuno-spaying of cull females. 200 heifers, averaging 230 kg were therefore vaccinated with Vaxstrate® in September and October 1991.
Results:
Although the vaccine was effective in suppressing oestrus, and the effects were reversible, the pattern of resumption of fertility was too irregular for the product to be of practical use for delaying puberty.

The average length of oestrus suppression was about a year, as planned. However half the first calves, from vaccinated animals, were born either earlier or later than the target season, with surprisingly little synchrony brought about by the seasons.

Discussion:
Out of season calving is as troublesome a problem as early calving, and no method of reducing variation in the vaccine's period of efficacy is apparent. Extending or shortening the activity period would not overcome that problem. It has been concluded that a successful method of delaying puberty in replacement breeders, without increasing the proportion of calves born in unsuitable seasons, would require a form of immuno-suppression in which the timing of reversal is initiated by intervention. Although there is a range of possible target sites for immunological control of fertility, and some of these show promise of more flexible control than the vaccine tested, the necessary delivery technology is still to be developed.

Present improved conditions in the beef industry may enable management to solve the problems of underweight replacement breeders. Better prices may allow high rates of selective feeding, and improved productivity should lead to a heifer surplus so weaner heifers in the critical weight range could be spayed or sold.

The 200 heifers, initially selected as an even line, now vary in liveweight between 270 and 450 kg, largely depending on their reproductive history. The final stages in the project are devoted to examining the effect of size on reproductive success.

Results of this project were presented at the 20th biennial conference of the Australian Society of Animal Production in Perth, July 1994 and published in the proceedings:

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The use of spike feeding of first calf heifers.

**Project Period**: 1993-1996

**Project Officer**: Neil MacDonald

**Project Location**: Kidman Springs

**Objective**: To assess whether spike feeding (a short term *pre-partum* nutritional boost) significantly reduces lactation anoestrus in first calf heifers, over a period of 3 years.

**Background**: Spike feeding is the feeding of a high energy supplement for about 50 days late in the dry season to cows in their last trimester of pregnancy. This appears to fire up reproductive hormone production and aid in early re-conception. By contrast, additional nutrition, *post-partum* is largely partitioned into milk production. The supplement is thought to equate to an early break to the wet season which many pastoralists accept as leading to improved calving in the subsequent year.

Expected benefits are up to 15% extra calves in the subsequent year and reduced out-of-season calving, from cows that conceive during the wet season rather than after weaning. This in turn may reduce breeder mortality.

While spike feeding could have an effect on cows of all ages, this trial focussed on first calf heifers because their usual re-conception rate is much lower than mature cows, and there is therefore more chance of the treatment being profitable.

Kidman Springs requires about 100 replacement breeders per year. Bulls are introduced into their segregated paddock each January and they are pregnancy tested in May or June. For this trial, the pregnant heifers are kept...
in Little Rosewood paddock, half on each side of a temporary electric fence. One group is fed from about 6 September to 26 October with 1.5 kg/day of a mixture of crushed sorghum and meatmeal, while the other group is not. To minimise paddock differences the two groups are rotated half way through the feeding period. Heifers are weighed at the beginning, middle and end of the feeding period.

Results:
This year's results were ruined by the earlier entry into the heifers' segregated paddock of a neighbour's bull. While none of the heifers should have started calving until after the end of feeding period, about half began to calve shortly after the start of the period. Also, by chance, most of the early calves fell in one of the two groups. This year's results were therefore invalid.

Discussion:
The spike feeding mixture costs about 60c/hd/day, amounting to $30 per head for the season. At present prices, it would require a 15% lift in branding rate from these heifers in the following year for the treatment to break even. Costs will probably restrict the use of this technique to producers who already carry out all other forms of improved management. Strong export demand for young cattle may make it more widely applicable in the future.

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Developing Survey and Sampling Techniques to Determine Nutrient Deficiencies in Cattle Herds.

<table>
<thead>
<tr>
<th>Project period :</th>
<th>1993-1997</th>
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</thead>
<tbody>
<tr>
<td>Project officer :</td>
<td>Neil MacDonald</td>
</tr>
<tr>
<td>Project location:</td>
<td>Katherine Research Station, Katherine meatworks, Mt. Sanford and elsewhere in the Katherine Region.</td>
</tr>
</tbody>
</table>

Objectives:
Examine existing techniques for determining nutrient deficiencies in cattle, identifying any worthy of wider application. To train extension officers on the techniques found to be of practical use. To further develop diagnostic techniques in cooperation with researchers elsewhere.

Background:
Nutrients of most interest in this region at present are phosphorus, fluorine, protein and energy.

It is clear that the Katherine Region and most of Northern Australia is generally phosphorus deficient. The industry's enormous expenditure on phosphorus supplements provides a strong incentive for the development of better techniques of diagnosing phosphorus status, although these have so far proved elusive. This project is collaborating with two national programs. One is attempting to assess bone mineral density in tails using a dual energy X-ray machine. For this program blood samples and tails were collected at the Katherine meatworks from 135 cows from 5 stations. Data on the cows' pregnancy status and age were also collected. The other program involves adjusting figures of blood inorganic phosphorus relative to the nitrogen content of the diet, as measured by simultaneous sampling of faeces. For this program, 80 blood and faecal samples were taken from supplemented and unsupplemented cows on the Mt Sanford demonstration in May 1994.

The risk of cattle suffering from fluorosis as a result of consuming phosphorus supplements with high fluorine contents has attracted a lot of attention in the last four years, and has resulted in a change to much more expensive sources of phosphorus, without much hard data being produced. Symptoms of fluorosis are teeth and bone abnormalities. During 1972-3, a few examples of teeth damage came to light, but it was not clear to what extent these were exceptional individuals with unusually high fluorine intakes. In May and June 1994, this project sponsored a study by a student from Emerald College, David La Fontaine, looking for signs of fluorosis in at a larger sample of cows off a number of stations in the region.

The pattern of seasonal deficiencies of protein and energy in the semi-arid region are well known. The main purpose in attempting to diagnose these deficiencies is as an extension tool to demonstrate the use and timing of supplementation. Samples of rumen fluid were extracted from cattle at Katherine Research Station over a few weeks in the wet season, but further development of the sampling technique is required.
Results:
The bone mineral density results found by the dual energy X-ray were not very useful as the variation within each herd was much greater than differences between herds.

The survey of signs of fluorosis found widespread teeth damage, in some cases to the extent that foraging efficiency would be compromised. Bone samples were also taken at Katherine meatworks to attempt to correlate teeth damage to bone fluorosis levels.

The preliminary study of rumen ammonia levels confirmed that protein levels in the diet become deficient by the middle of wet season, and therefore effective wet season supplementation must include some urea.

Conclusion:
The technique for assessing phosphorus status with most potential appears to be the use of blood phosphorus correlated with faecal nitrogen. It now appears doubtful that the dual energy X-ray technique will prove useful, mainly because the relationship between bone mineral density and phosphorus status appears to be less close than originally suspected.

The fluorosis survey is of great interest, but it is not certain how much further the subject needs to be pursued, as the industry has accepted that MAP-based phosphorus supplements pose unacceptable risks. Techniques for sampling of rumen fluid for protein and energy will be developed further.

♦♦♦ A Best Bet Management System for a Self Replacing Breeder Herd in the VRD

Project Period: 1990 - 1994
Project officer: Rohan Sullivan
Project location: Victoria River Research Station (Kidman Springs)

Objective:
Measure the productivity of a breeding herd in the VRD run according to DPIF recommendations and assess costs and returns particularly those associated with the use of supplements.

Background:
The major emphasis of work at Kidman Springs during the past decade has been on weaning and its effect on breeders and progeny. While having significant benefits for breeding cows in reducing mortalities and improving fertility it also has negative aspects (Sullivan et al 1992). These include reduced growth rate in progeny and out of season calvings.

Despite the emphasis on weaning along with control of botulism at Kidman Springs, breeder productivity in the main experimental herd had not improved much above the traditionally accepted figures for brandings and mortalities in the VRD of 45% (Robertson 1982) and 10-15%. It is likely that the absence of supplementation limited the productivity of the herd (Sullivan and O’Rourke in prep.). A small group of supplemented cows at Kidman Springs averaged 70% branding and 2% mortalities over 4 years from 1986.

Use of supplements for breeders in the Katherine region is becoming more widespread. However little objective information is available on the cost/benefit ratio of supplementation. This project is designed to provide information on the costs and returns associated with supplementary feeding and monitor herd performance under recommended management.

Materials and Method:
A herd of 500 Droughtmaster cows and their progeny are run under the following recommendations.
- Mustering and weaning twice annually (April and September).
- Calves weaned to 100 kg and grazed on spelled native pasture.
- All stock supplemented on a year round basis. Non protein nitrogen (urea) based licks during the dry season and phosphorus during the wet. True protein and energy for first calf heifers and for small weaners or crisis feeding if required. Initially budgeted for $15 per cow/year.
- Cows culled at 10-11 years of age or for injury, temperament or barrenness.
- Heifers selected at 2 years based on liveweight, temperament and general conformation.
Heifers mated in February and run separately until weaning first calf. Bull ratio of 5% continuously mated. Annual vaccination for vibriosis and culling for injury, temperament, age (8-9) or sub-fertility after testing. All stock vaccinated annually for botulism strains C and D. Use of fire to manage pastures. Cow numbers limited to 500 with enough replacements to cover mortalities and culls.

At each muster weight, condition score, pregnancy and lactation are recorded as appropriate. This data is used to calculate branding and mortality rates and monitor growth and conception rates.

Progress Report:
The herd at Kidman Springs has shown marked improvements in productivity since this study was commenced in July 1990.

Weaning and mortality rates at Kidman Springs.

<table>
<thead>
<tr>
<th>Year</th>
<th>Weaning rate (%)</th>
<th>Mortality rate (%)</th>
<th>Supplement cost per cow ($)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985 - 1990 Average</td>
<td>51</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>1990 - 91</td>
<td>52</td>
<td>4.5</td>
<td>19</td>
</tr>
<tr>
<td>1991 - 92</td>
<td>85</td>
<td>2.5</td>
<td>17</td>
</tr>
<tr>
<td>1992 - 93</td>
<td>68</td>
<td>3.7</td>
<td>18</td>
</tr>
<tr>
<td>1993 - 94</td>
<td>80</td>
<td>2.2</td>
<td>14</td>
</tr>
</tbody>
</table>

* Supplement cost is for purchase only, transport and distribution have been estimated at $6.50/cow/year.

As shown in the table, mortalities have fallen substantially and weaning rate increased since the commencement of the study. The initial aim was to improve productivity to average 70% weaning and 6% cow mortalities. A very low wet season rainfall in 1991-92 may have adversely affected the 1993 figures for weaning. The mortality figure was better than expected considering the poor seasonal conditions. It is planned to continue the study until September 1994 to allow the effect of the 1991-92 wet to pass and achieve the objective for weaning rate. The cost of supplement has exceeded the initial budgeted figure of $15 in all years except 1993/94. Factors contributing to this have been higher than expected consumption rates, requirements for true protein and energy feed in 1992-93 and rising prices for ingredients. Costs were expected to fall for 1993/94 due to better seasonal conditions and steadier consumption patterns.

PROGRAM 3 POST WEANING STUDIES

ожож A Scenario for the Northern NT Beef Industry

Project Period : 1993/94
Project Officer : P E R Ridley
Project Location: Katherine region and the Daly Basin

Objective:
(i) to provide a response to the question: 'What will be the structure and market focus of the beef industry in the northern NT in the year 2003?'
(ii) to identify projects / activities which the Katherine Pastoral Division should undertake to facilitate the anticipated transitions and thus contribute to industry prosperity,
(iii) to assess industry views on the conclusions drawn about (i) and (ii) above.
Background
This project is part of the Department’s program ‘Meeting post weaning market specifications’.

The northern NT beef industry has recently emerged from its enforced preoccupation with the BTEC campaign. It is experiencing the strong market pull forces of SE Asia’s rapidly expanding demand for beef. This demand is being driven by rapidly improving incomes in most of the region, the high status of beef as a food item and government policies there aimed at improving animal protein intakes in the human populations.

These important factors are likely to ensure SE Asia’s continuing interest in importing cattle rather than meat. These are:
- the employment opportunities created when cattle are fattened and slaughtered in the country where their meat is to be consumed,
- the wide range of products other than cuts of meat that can be used and sold when the cattle are slaughtered in the importing country.
- the large volume of agricultural waste (eg. poultry manure, pineapple pulp etc.) than can be profitably disposed of with negligible environmental cost through cattle in feedlots.

The northern NT beef industry is both favourably located from a transport point of view and well endowed with suitable breeding country and suitable cattle breeds, to take advantage of SE Asia’s increasing prosperity and increasing demand for beef.

Results:
This project has identified:
- the potential for specialisation and the more widespread implementation of the Department’s Kidman Springs management package, to more than double the annual output of store weaners from the northern NT beef industry, (from 75,000 to 163,000),
- the importance of the retention of an export registered abattoir in the northern NT to improve the viability of cull cow disposal and keep open future value adding options (eg. table beef for export or the Darwin fresh meat market)
- the need for comprehensive R and D work aimed at optimising the profitability and year round supply of feeder steers from growing enterprises on improved pasture in the Daly Basin. These enterprises will utilise pastoral weaners bred on native pastures and will be the driving force behind the move to specialisation.
- the need for up to 175,000 ha of improved pasture in high rainfall areas with suitable soil type (eg. the northern Daly Basin) if the trend to specialisation is to reach its full potential in the northern NT beef industry.

A group of 24 key industry personnel (producers, processors, agents etc.) have been surveyed for their response to the scenario. The results of this survey have yet to be analysed. They will be reported in the 1994/95 technical annual report.

******** Feeder Steer Farmlet DDRF

Project Period : 1992/93 to 1996/97
Project Officer : P E R Ridley
Project Location : Douglas Daly Research Farm

Objectives:
(i) to demonstrate on a commercially credible scale what is currently thought to be the most profitable post weaning production system for feeder steer production in the northern Daly Basin.
(ii) to acquire data on:

- between year differences in the pattern of turnoff,
- the percentage of carry over steers,
- the longer term sustainability of the system,
- the between property differences in growth rate in commercial weaners purchased for the project.

**Background:**

This project is part of the Department’s Program ‘Meeting Post Weaning Market Specifications’.

If the northern NT beef industry is to realise the opportunities created by the rapidly expanding market for live feeder steers in SE Asia, it will need to use the specialisation approach that is well established in the Barkly. There native pastures are primarily used for breeding and weaners are transported elsewhere for growing out (on improved pastures) and fattening (on improved pastures or in feedlots).

In the case of the northern NT beef industry (Darwin, VRD, Gulf), the Daly Basin with its favourable rainfall and soils represents a unique opportunity for profitable productive improved pasture development for growing out weaners.

If specialisation were totally implemented in the northern NT beef industry, the results could be:

- more than double the number of store weaners available for growing out each year (from 76 000 in 1992 to 163 000),
- an increase of 35% in the northern NT cattle carrying capacity through the development of 175 000 ha of improved pasture in high rainfall areas (eg. Daly Basin).

**Results:**

Preliminary estimates using data from this project show:

- annual weight gains of 110 - 115 kg / hd or 125 - 135 kg / ha can easily be achieved on buffel pasture by average (180 - 190 kg) Brahman weaners from commercial cattle stations in the Katherine Region (VRD, Gulf),
- the growth rate differences of unselected groups of weaners from the eight properties so far compared are negligibly small,
- matching initial weights (140 - 180 kg) with potential annual weight gains (140 kg / hd / yr) is of crucial importance in determining annual productivity per hectare and thus potential profitability,
- when weaner and turnoff feeder price per kg live weight are equal and fall in the range $1.00 to $1.20, return to capital to this feeder steer enterprise is likely to fall in the range 10 - 15%.

During the next three annual cycles of production, this project will compare two groups of weaners each year. One group will be unselected (ie. proportional numbers from all weight ranges from each property of origin), with a second (selected) group of the same initial total weight but only drawn from 140 - 180 kg weaning weight steers. Data from this work will be used to recalculate potential profitability. If productivity increases to 140 kg / hd / yr or 170 kg / ha / yr as seems possible with the selected group, gross returns at $1.30 / kg live weight could increase by $50 / ha.
ALICE SPRINGS PASTORAL DIVISION

Cattle numbers throughout the Alice Springs District continued to be maintained at low levels, as a reflection of continuing drought conditions.

Eight cattle sales were held at the Bohning Cattle Yards at Roe Creek, Alice Springs in 1993-94.

Good rains recorded in Queensland and New South Wales at the beginning of the new financial year created good demand for cattle at the Bohning Cattle Sale Yards in August 1993. The highest liveweight prices were paid by Queensland meat buyers.

At the end of 1993, the lack of follow up rain in Queensland stemmed the flow of store cattle east. Drought conditions persisted over large areas of Queensland early in 1994. During the first six months of 1994, up to 40% of cattle inspected and certified in the Alice Springs District, were destined for Queensland markets and saleyards.

Demand for Alice Springs District cattle by South Australian Markets was steady with the high prices paid for fat and store cattle at sales throughout 1993-94.

The movement of Queensland cattle presented a problem with the presence of burr and need for burr inspections.

Several mobs of cattle from Western Australia TB Free properties were trucked to Alice Springs for the cattle sales at the Bohning Cattle Sale Yards.

Enquires by a NT pastoralist and local livestock agents, regarding export of store cattle to Japan, were terminated when it was discovered that the Alice Springs Airport runway was not long enough to accommodate the freight plane required.

Table 1.- Alice Springs District Cattle Sales - Bohning Yards 1993-94

<table>
<thead>
<tr>
<th>CATTLE SALE DATES</th>
<th>CATTLE TYPE (fats, stores)</th>
<th>CATTLE NUMBER(hd)</th>
<th>TOP PRICES per kg</th>
<th>TOP PRICES per hd</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/7/93 stores</td>
<td>2 528</td>
<td>$1.15</td>
<td>$342</td>
<td></td>
</tr>
<tr>
<td>26/8/93 mixed</td>
<td>3 636</td>
<td>$1.30</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>16/9/93 mixed</td>
<td>3 492</td>
<td>$1.29½</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>23/9/93 mixed</td>
<td>3 017</td>
<td>$1.37</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>24/3/94 mixed</td>
<td>2 866</td>
<td>$1.42½</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>14/4/94 mixed</td>
<td>3 043</td>
<td>$1.45</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>28/4/94 mixed</td>
<td>2 265</td>
<td>$1.30</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>30/6/94 stores</td>
<td>2 943</td>
<td>$1.28</td>
<td>$384</td>
<td></td>
</tr>
</tbody>
</table>

Horses
Horses inspected through the Bohning Cattle Yards, Alice Springs in 1993-94 totalled 1 395 head.

Camels
Wamboden Abattoir processed 401 head of camels in the 1993 calendar year. Live camels were trucked from the Alice Springs District to Indonesia(20 hd), Peterborough, SA(12 hd) and other interstate
destinations (est. 40+hd) in 1993-94.

Other
Other stock inspected through Alice Springs included;
· Buffalo from the Top End of the Territory, spelled at Alice Springs in transit to destinations in New South Wales and South Australia.
· Donkeys, trucked to New South Wales.

Economic Conditions
Many Alice Springs Pastoral Properties continued to experience the combined effects of drought and recession. Central Mount Wedge and Ambalindum Stations were put up for auction, but were passed in without an acceptable offer of sale. Tempe Downs, Loves Creek and Angas Downs Stations joined Alcoota on the list of pastoral properties recently sold to Aboriginal concerns.

New Industries
Recent interest in emu and ostrich farming has stimulated enquiries about the viability of such enterprises in the Alice Springs District.

ANIMAL HEALTH
Reported under Animal Health Division

RANGELAND PRODUCTION

**Exclosures**

<table>
<thead>
<tr>
<th>Project Period</th>
<th>1958 - 1994</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Officer</td>
<td>Nathaniel Last (Until November, 1993) Mark Ashley (From December, 1993)</td>
</tr>
<tr>
<td>Project Location</td>
<td>Alice Springs District</td>
</tr>
</tbody>
</table>

Objectives:
Maintain as long term reference areas, secure and accessible portions of country which are representative of the broad, pastorally productive land types in the district.

Demonstrate and document the effects of grazing by direct comparison of grazed and ungrazed portions of the same land type.

Demonstrate and document the relative responses to pasture improvement practices on grazed and ungrazed treatments.

Background:
While exclosures can be used, in part, to achieve all of the objectives enunciated above, the focus during the current year has been on partitioning the effects of season and the impact of livestock. Currently the project monitors 15 long and short term exclosures.

Results:
Vegetation yield and composition were recorded inside and outside of each of eleven long term exclosures in February-March, 1994 and again in April-June, 1994. A consistently dry summer prevented any meaningful seasonal differences between assessment dates from being evident in the results.

Five of the eleven exclosures had an average of 380 kg/ha more pasture on the (ungrazed) inside than on the adjacent grazed outside. The forb : grass ratio of these pasture types was typically 1 : 2.25. Another five exclosures, experiencing grazing pressure, had an average of 100 kg/ha more pasture on the outside than on the
inside. One exclosure is subject to negligible grazing pressure.

Spelling has been advocated as a management tool to promote pasture regeneration. The results obtained thus far in this project suggest that pasture spelling does not always result in pasture improvement. Its effect is dependant upon site specific rainfall events.

A report summarising all results obtained to date is being prepared. The future of each of these study sites will then be considered.

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Satellite Remote Sensing

**Project Period:** 1991-1994  
**Project Officer:** Rik Dance  
**Project Location:** Alice Springs and Barkly Districts

**Objective:**  
To evaluate and, where appropriate, adopt information sources based on satellite remote sensing.

**Background:**  
Northern Territory Government agencies with responsibilities for rangeland management and use in Central Australia have few staff to devote to research and advice. Satellite remote sensing offers advantages through repetitive imaging of the earth's surface. There is a body of research on applications of satellite remote sensing to the mapping and monitoring of the rangelands of Australia, but little adoption of this research.

**Results:**  
Essential work for the two existing components of this project was completed by 30th June 1993, and is summarised in the 1992/93 Technical Annual Report. The then project officer (Guy Hodgson) terminated his employment with the NT Government at that time. The two internal reports which he produced are of a high standard but require minor editorial work prior to publication. There are also some funds remaining against the project budget which are held primarily by the Conservation Commission of the NT.

The necessary editorial preparation for publication has not been given high priority, and is not complete. Agreement with the Conservation Commission has been reached regarding the nature of the final phase of the work, but they have not appointed an officer to undertake it, and thus no effective progress has been made in this year.

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Range Condition Assessment (RCA)

**Project Period:** 1976 - 1994  
**Project Officer:** Rik Dance  
**Project Location:** Alice Springs District

**Objectives:**  
Record, interpret and provide timely feedback to producers about changes in grazed rangeland which are attributable to seasonal and management factors. In particular to:

- Monitor rangeland responses to season, management practices and other appropriate phenomena.
- Derive relationships between management practices, season and the value of rangeland as a grazing resource.
- Provide advice to pastoralists and government agencies on the productive utilisation of the area's resources.

**Background:**  
RCA activities focus on fixed, 10 hectare sites, but relate the site specific details to the wider area. Sites are established on high productivity land systems or those areas likely to be sensitive to seasonal and management
influences. The sites are reassessed at intervals of one to ten years using procedures outlined by Bastin (1989). Principally, sites are photographed and detailed information is collected on soils, herbage, shrubs and trees. Site inspections and discussions with landholders provide information on rainfall, fire and grazing histories. Some sites have rain gauges. The field observations by graziers can provide an important insight to rangeland responses to episodic events and producers are encouraged to revisit and re-photograph sites at frequent intervals. This project is conducted on a lease by lease basis and operates within a framework of goodwill, professional advice and encouragement. The Rangeland Production section strives to involve and inform pastoralists in all aspects of the project's field activities.

All data is stored on computer and photographs are archived to facilitate longer term comparisons. Site data is analysed by comparison to notional benchmarks, coupled with the photographs, and presented in confidential reports to the properties. Within these reports the results and findings are interpreted within practical productivity and management frameworks. The reports are individually discussed with landholders and many sites are jointly evaluated so that practical and productive management options can be developed. The monitoring of subsequent land management or pasture improvement projects is also undertaken.

This project has been instrumental in developing and increasing awareness within the industry of numerous production issues. Most of the section's producer demonstration sites and specific research projects are direct results of this project. Some important rangeland production subjects which have been highlighted and are being addressed elsewhere are:
(a) Increase to excess of a range of tree and shrub species.
(b) Management of perennial grasses.
(c) Location of water points.
(d) Reclamation of degraded areas.
(e) Pasture spelling
(f) Tailoring season of use and livestock classes to types of country.

Results:
A number of factors led to the effective suspension of this project for the year, apart from reporting commitments to landholders related to 1992/93 data collections. Staff training and turnover, generally poor seasonal conditions, confusion about agency roles, and queries about outcomes all contributed.

As a consequence, it was decided to thoroughly reconsider the objectives and commitment to this type of work. Both the Alice Springs Pastoral Industry Advisory Committee and the Centralian Land Management Association have been consulted and have indicated continuing strong support, although detail of the services that might be provided in the future are yet to be considered. Similarly, negotiations have commenced with the NT Pastoral Land Board.

During the year, Land System mapping of the Alice Springs region was made available to the Department of Lands and Housing in connection with their land monitoring function. The Pastoral Land Board requested landholders to authorise the release of confidential information held by the Department, but no action has resulted.

* * * Green Cover Reporting

Project Period : 1989 - 1994
Project Officer : Rik Dance
Project Location: Alice Springs

Objective:
To develop and verify seasonal indices of rangeland pasture growth in Central Australia.

Background:
The most significant determinant of variation in production from the grazing industry, both in space and in time,
is recognised as being that which is due to variation in the suitability of climatic conditions for plant growth. Any action taken by man to enhance the utility of rangelands for livestock is secondary to unpredictable, unreliable and uncontrollable weather influences. It follows that to make any intelligent interpretation of the effects of management, quantification of seasonal conditions is essential. There is currently no altogether satisfactory means of doing this. The available information is either qualitative, spatially sparse, or lacks an adequate interpretation model.

The use of satellite based indices of plant growth provides an opportunity to record production on a regional scale at the "grass roots" stage. Although technical problems persist, this project has already demonstrated the potential of this approach for Central Australia. Other States, and the Commonwealth, have also developed expertise in this area, for their own purposes.

Green Index images generated for the Alice Springs area have frequently displayed apparently unexplained mild but significant fluctuations which are unrelated to any clear biological or rainfall phenomenon. Before proceeding to the multitemporal classification of NDVI image data to provide indices of seasonal conditions, it is desirable to produce a more reliable and consistent product. Preliminary investigations in 1990/91 revealed that brightness temperature differences between AVHRR channels 4 and 5 related reasonably well to the apparent inter temporal noise, and might form the basis for a radiometric correction. As reported in the 1991-92 report, AVHRR channel 4 and 5 radiance differences (deltaR) proved superior to brightness temperature in accounting for intertemporal variation in NDVI and hence for producing a more stable product.

Results:
The year was characterised by emerging problems with the production of a reliable and consistent product, due to changes in satellite orbits, and changes in the availability of data.

There are now essentially three different data sources:
1. Single overpasses acquired directly from a receiving station, in an unprocessed form. This has been the data source used continuously since 1989. It is the most timely, with a product available for use within days of acquisition. In practical terms this approach is dependant on the ability to purchase scenes which are free of cloud, or have limited cloud in known locations.

2. Multiple overpasses, processed and geocoded elsewhere. These are "maximum value composited" over a period of approximately 14 days to produce a "cloud minimised" product for that period. This product is generally not available till more weeks after seasonal events due both to the compositing period, and the volume of pre-processing which is required. At the end of the period the product may still contain significant cloud, and may be no better than the single overpass product. It is also the nature of composite products that they invariably contain join lines between adjacent component images.

3. A composite product similar to 2 but with the additional application of algorithms to adjust radiometer counts for sun-ground-satellite geometry. These algorithms (which are highly technical and necessarily make some assumptions about the properties of the atmosphere), are not fully understood. An attempt to reproduce them using the original published scientific work, was a failure, so for the moment, they represent a "black box". Recent scientific opinion questions whether they necessarily improve data quality.

Data from all of the above sources was acquired during the year.

To complicate the issue further, NOAA 11, the satellite which we have used since 1989, declined in utility during the year, and became unusable at year's end. The reason for this has been a slowly changing orbit, (which cannot be corrected), which is causing its overpass time to become later and later each day. At the end of this reporting year its overpass was late in the afternoon, when the low sun angle severely interfered with the quality of the data for this project. The late overpass time also undoubtedly contributed to the significant problems with cloud which were experienced this year. Alternative satellites (NOAA 12 and NOAA 9), are available, but there are difficulties in obtaining suitable data, and the data which is available is known not to be directly comparable with the NOAA11 data used previously.

In the face of this uncertainty, attempts were made to explore the utility of all available data sources. Direct
translation between type 1 and type 2 (above) proved possible, but the interconversion with type 3 is date dependant. The best source for future data acquisition was thus very uncertain at the end of the year.

Single overpass data from NOAA 11 was acquired for 7 dates. The presence of cloud, (which was probably exaggerated by the late overpass time), allowed only 3 products of suitable quality for release to the public to be generated by compositing together data from consecutive days. A number of composite products (Type 2 and 3, above), were acquired, one of which (of type 2) was released to the public.

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**Economics of Tree and Shrub Control**

**Project Period:** 1987 - 1995  
**Project Officer:** A White (1993), G Bohning (1994)  
**Project Location:** Alice Springs District

**Objective:**
Continue to evaluate and report on the costs and returns of the use of herbicides and mechanical methods for the control of excess woody vegetation in the Alice Springs area.

**Background:**
Unnecessary woody vegetation competes with native pasture for moisture and nutrients, restricting pasture growth and rendering paddocks less productive. Mechanical methods of control such as chaining and blade ploughing are recommended, as is the use of fire, however limited data has been recorded on the costs and benefits of these control methods. Granular herbicides have been proposed as an alternative to these methods with the advantages of being very fast to apply, achieving a high level of control, not requiring expensive application equipment or for country to be locked up for extended periods. The costs of control vary with the treatment method, but a similar pasture response, and hence return, may occur regardless of the method of control.

Trials using Graslan® commenced at Alcoota station during 1987 on target species mulga (*Acacia aneura*) and ironwood (*A. estropholiata*) and on Stirling station in 1989 on ironwood and witchetty bush (*A. kempeana*). When it became obvious that ironwood control was achieved even at the lowest application rate of 3.7 kg/ha, additional plots (below 5 kg/ha) were established early in 1992 on Alcoota and Stirling stations to determine the lowest and most economical application rate of Graslan® to control dense juvenile ironwood, without killing mature trees and leaving the soil surface bare.

To examine the effect of mechanical thinning of trees and shrubs, there are 26 assessment locations arranged as 14 pairs of a treatment site and a nearby control, with some treatment sites sharing the same control. Two additional treatment and control pairs were selected during the year in anticipation of treatments being imposed. No results are reported here for those locations.

**Results:**
Results obtained in April 1993 at Alcoota have been reported in the previous Technical Annual Report. Pasture yield increases of 250-300% were recorded when ironwood was controlled with Graslan®. There has been no subsequent measurements taken during the period of this report.

As a consequence of Graslan® application to ironwood in 1989 at Stirling, mean pasture yield was recorded at 2007 kg/ha in July 1993, compared with 991 kg/ha where no herbicide had been used. Perennial grasses made up 92% of the yield where the treatment had been applied, but only 54% where it had not.

As a consequence of Graslan® application to witchetty bush in 1989 at Stirling, a mean 130% increase in pasture yield was recorded in July 1993, but with the proportion of perennial grass well depressed by the treatment in favour of annual grasses. Significantly higher Graslan® application rates were used against witchetty bush (mean 7.6 kg/ha), compared with that used against ironwood (mean 4.3 kg/ha).

Following Graslan® herbicide application at rates between 1.2 and 4.9 kg/ha to ironwood in 1992, total pasture
yields of 1021 kg/ha to 1438 kg/ha were recorded on the treatments (mean 1275 kg/ha), compared with 883 kg/ha where no herbicide had been used, a mean treatment response of 144%. Average tree kill was 54%, but may increase with time, as the herbicide continues to take effect.

Differences in herbicide application rate within the range 1.2 to 4.9 kg/ha seem to have been unimportant so far, for either tree kill or pasture yield, confirming that very low rates of Graslan® may be most appropriate for ironwood control.

Despite the low application rates used, the proportion of perennial grass in the yield has been depressed by the herbicide applied, at this stage.

The mechanical treatments being considered are those imposed by pastoralists in the course of their year to year property management. These are:

- Chaining;
- Blade ploughing;
- Blade ploughing and sowing with buffel grass.

These treatments have been imposed at various dates to plant communities dominated by:

- Gidyea (*Acacia cambagei* and *A. georginae*)
- Witchetty bush;
- Ironwood;
- Mulga

Results are available for all locations for 1993, and some for 1994:

**Chained gidyea:**
At 5 of 6 locations an increase in pasture yield attributable to the chaining treatment was demonstrated. The increase ranged from 30% to 156% with a mean of 60%.

**Chained mulga:**
The mean increase in pasture yield attributable to chaining in 1989, at 4 locations was 219% in 1993, and 382% in 1994.

**Chained witchetty bush:**
A mean increase in pasture yield of 163% attributable to chaining was recorded.

**Blade ploughed ironwood:**
This treatment was imposed in 1991 and resulted in a 180% increase in pasture yield, recorded 2 years later.

**Blade ploughed mulga sown to buffel grass:**
A mean pasture yield increase of 108% was recorded at 2 locations, in the year of the treatment.

At some chained mulga sites however, despite the increased pasture yield, an increase in juvenile mulga density was also recorded, suggesting that the destruction of mature mulga, and soil disturbance, has favoured not only the pasture, but the establishment and growth of the mulga as well. Caution may need to be exercised with mechanical control under some circumstances.

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**Seasonal Monitoring Sites**

- **Project Period:** 1983 - 1994
- **Project Officer:** Rik Dance
- **Project Location:** Alice Springs District

**Objectives:**
- Characterise the seasonal changes in biomass, composition and pastoral value of three important pasture communities in central Australia.
- Evaluate the effectiveness of multi-variate statistical techniques in separating the relative influences of grazing and season upon these three communities.
Comment upon the degree to which intensity and duration of grazing during adverse seasons, influences subsequent vegetation responses.

**Background:**
Accurate information on changes within the forage base is necessary for the development and promotion of sound grazing management practices. Season (amount, intensity and timing of rainfall) is the largest contributor to change. The pastoral community has a right to expect interpretations about the causes of change in their land resources to be based on sound and objective methods. This project is describing and categorising such changes and is testing objective methods of interpreting causal relationships.

The project is planned to continue until a good summer season similar to that experienced in 1982/3 is again evident.

**Results:**
Due to continuing poor seasonal conditions, data collection has not been regarded as a priority and was not undertaken during the year.

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**Needlebush Rabbit Control**

**Project Period:** 1991 - 2000
**Project Officers:** A White (1993), G Bohning (1994)
**Project Location:** Alice Springs

**Objective:**
To undertake an evaluation of the effect of rabbit eradication on vegetation in the Centralian Land Management Association (CLMA) Needlebush Rabbit Eradication Project.

**Background:**
CLMA has established a 250 km² rabbit eradication area in the vicinity of Mt Ebenezer. The overall objective of the CLMA program is to show, by establishing a demonstration on this extensive scale, the ecological and economic benefits of combined rabbit eradication and associated grass planting in an area of low and unpredictable rainfall. The role of the Department is to measure the vegetation response following the removal of the rabbits and calculate the costs and benefits of this control operation.

**Results:**
Rabbit numbers continue to be quite low throughout the area, having minimal impact. In July 1991, after eradication had commenced, there were between two and 12 rabbits observed per linear kilometre, with numbers falling rapidly thereafter on both the treated and untreated areas, due to hot dry summers, unfavourable to rabbit survival.

From the end of 1991 till about August 1993 rabbit numbers remained mainly around zero, but occasionally up to 0.5 per linear kilometre on three of the four transects in the eradication area. The fourth transect in the eradication area experienced a much slower decline in numbers and thereafter had a larger number of rabbits observed than the others, but still no more than about 0.5 per linear kilometre. By March 1994, and again in May 1994, rabbit sightings on some transects in the eradication area had risen to 1.2 per linear kilometre. During the same period there were between about 0.5 and 1.5 rabbits observed per linear kilometre in the untreated area, rising to almost 3 per linear kilometre in May 1994.

Thus while there was a rapidly declining population in all areas from late 1991, numbers though continuing to be quite low, are higher in the untreated area, and have risen in all areas in early 1994.

Treatment impacts on pasture parameters were recorded on 2 occasions during the reporting period, once in September 1993, and again in April 1994. Total pasture yield recorded on the eradication area increased from 508 kg/ha in 1992, to 748 kg/ha in 1993, and to 916 kg/ha in 1994. Total pasture yield recorded on the untreated area was relatively constant at 1054 kg/ha in 1992, 1122 kg/ha in 1993, and 1166 kg/ha in 1994.

This apparent anomaly is explained by the low overall rainfall and consequent very low rabbit population.
Rabbit numbers are too low to be having much influence on pasture and all the influence comes from area variation in rainfall. Thus the improving pasture yield on the eradication area is largely attributed to better seasonal conditions experienced there during the period. In the 1992/93 Technical Annual Report, the low yield on the eradication area was explained by the lower rainfall that this area received in the October to November 1992 period. Similarly, for calendar 1993, 204 mm of rain were recorded at site 37 within the eradication area, while only 13 mm to 96 mm were recorded for the same period at sites within the untreated area.

At the 1993 assessment, only 1 to 3% of the pasture was grass. The rest was forbs predominantly *Sclerooleana* spp. By the April 1994 assessment, there had been some summer rainfall (see below), and 11 to 12% of the pasture was grass. There are no treatment effects evident. Buffel grass continues to establish well and was seen to be spreading beyond the ripped warren areas. It was estimated to have an establishment rate of around 15 - 20% in 1992. This would be well surpassed in 1993 with favourable rains encouraging further good germination and seed set.

A further 8 assessment sites were established outside of the eradication area during 1993, bringing the total number of such sites to 18. There are 10 sites within the eradication area. All are fenced to exclude cattle, to avoid any differences due to cattle grazing. Results from these additional locations have not been included in the results presented above.

From late December 1993 until March 1994, seven of these eight new sites received much more favourable rainfall than elsewhere (65 mm over 10 days, compared with 17 to 45 mm over 5 to 9 days). Not surprisingly, the pasture yield at these sites was well elevated at the assessment in March 1994 at a mean 1404 kg/ha.

The Spanish rabbit flea (*Xenopsylla cunicularis*) was released approximately 80 km from this project area during April 1993. It is reported to have established well and to be spreading at a rate of around 2 km per annum. The flea has yet to be inoculated with the myxoma virus and would therefore have had no effect on the rabbit population even if it had spread to the needlebush area.

In summary, rainfall differences are believed to be having a much greater impact than the relatively few rabbits. It will not be until conditions favourable to a build up in the rabbit population persist over a number of years, that their impact is likely to be measurable.

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**Introduction to Pasture Species**

**Project Period:** 1991 - 1995  
**Project Officer:** Rik Dance  
**Project Location:** Alice Springs

**Objective:**
Develop a proposal to evaluate the production potential of existing and new introduced pasture species for Central Australia.

**Background:**
In the 1960's, CSIRO Alice Springs, undertook to evaluate the potential of perennial grass species from overseas for the pastoral industry of Central Australia. Of the 135 lines tested, 45 failed to germinate, 17 germinated and established but failed to survive, and 58 established and were assessed. (Millington and Squires, 1980). Of the 7 successful grasses, 4 were varieties of buffel grass, which has been widely planted and has naturally spread through the district, one was birdwood grass, which though planted subsequently, is not as prolific as buffel grass. Blue panic (*Panicum antidotale*) was used in seed mixtures for dust control plantings around the Alice Springs Airport. The other apparently promising species was *Lasiurus sindicus* which as far as is known, has not been planted to any great extent at all.

In summary, of the 145 introductions by CSIRO, 30 years ago, none has proven to be greatly superior to a species which had been accidentally introduced many years previously.
Other states (notably Queensland) have continued to screen plants for similar areas, and it is considered timely to collate the available information, and, should any promising species be identified, to demonstrate and evaluate them locally.

Results:
The proposal is still in draft form. There has been no further action during the year.

### Water Harvesting

**Project Period:** 1994 - 1994  
**Project Officer:** Peter Harrison  
**Project Location:** Alice Springs

**Objective:**
- Provide an account of the current state of knowledge of the practice of water harvesting as it applies to, or is likely to apply to, Central Australia.
- Detail the extent and nature of adoption of water harvesting technology in Central Australia, including both water ponding banks and other similar techniques, including difficulties and problems.
- Elucidate industry perceptions of the concept, including attitudes, knowledge and needs.

**Background:**
Water harvesting is not a new concept. In arid and semi-arid Australia, interest dates from about the 1960s. A number of techniques have been used, from single furrows to more complex and comprehensive ponding banks and in the last twelve months there has developed considerable interest in waterponding technology.

Historically, much of this activity and interest has its roots in erosion control and the message has been driven by primarily land and soil conservation agencies. This has often meant the worst or most eroded areas are of primary interest. There is a school of thought that sees some of the water harvesting practices as having a significant production aspect with some suggesting that less severely degraded areas are likely to provide the best economic return from regeneration projects.

**Results:**
A report has been prepared for the Department, as a basis for the future project funding decisions. It covers such subjects as:
- Ecological principles and processes involved;
- Bank construction;
- Role in risk management;
- Role of rainfall;
- Economics;
- Agronomic issues;
- Knowledge gaps.

This project is now complete.

### National Drought Alert Strategic Information System

**Project Period:** 1994-1995  
**Project Officer:** Daniel Brock  
**Project Location:** Northern Territory

**Objective:**
To contribute to the development and application of a national model for the prediction of pasture growth and utilisation associated with drought.
Background:
Queensland researchers believe that drought may cause land degradation if there is an imbalance between stock numbers and available feed. They believe that in 1982/3 a widespread drought, led to severe overgrazing in the Dalrymple shire of Queensland, and a change in the major pasture species from kangaroo grass to unpalatable spear grass.

The Queensland Department of Primary Industry (QDPI) have developed a spatial plant growth and utilisation model that aims to predict drought events and potential land degradation. The National Drought Alert Strategic Information System (NDASIS) is an attempt to operate this model at a national scale.

The NDASIS model will be run on a daily basis and is intended to generate maps of predicted feed deficit. It may be run in a predictive manner for up to 90 days in advance, although this is clearly dependant upon the ability to predict future weather conditions. Outputs of the model will be presented on a 5 km grid nationally. The model requires a number of inputs including:
- pasture community types
- soil water and physical parameters
- stock densities
- daily rainfall and other meteorological recordings

The role of the Northern Territory DPIF as part of the national project is to:
- provide the necessary NT model inputs (where available)
- validate model predictions
- determine future applicability for the N.T.

Results:
A database containing daily and monthly rainfall recordings for the previous five years has been established. It is intended that daily rainfall records will be kept up to date for all pastorally important rainfall recording stations in the NT. This database has been used to compare daily rainfall recordings that QDPI receive from the Bureau of Meteorology (BOM), Melbourne for the NT, to check the accuracy of rainfall inputs into the NDASIS model. Currently monthly rainfall recordings are sent to QDPI as soon as they are available.

A digital map of 112 vegetation types was obtained from the Conservation Commission of the NT. The 112 vegetation types have been reclassified into 35 pasture communities based on potential carrying capacity and vegetative similarity. Software and hardware limitations have caused significant additional work, and consequent delays, in transferring the data between systems, in converting its data structure and compiling it in a suitable digital format.

Australian Bureau of Statistics (ABS) stock numbers for all local statistical areas in the NT have been obtained. The stock grazing preference of each of the vegetation communities, and the distribution of stocked vs non stocked land, have been estimated and used to redistribute stock numbers within each statistical area. Conversion of the resultant estimated stock distribution data into a digital map form has been delayed by the problems mentioned above associated with the creation of the digital pasture communities map.

There is no consolidated digital soil database for the NT. A review of the available research has also indicated that there has been little investigation of the soil water parameters required as inputs for the NDASIS model. At this stage soil data for the NT will be based on Northcotes’ Atlas of Australian Soils, and estimated soil water parameters.

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Establishment of Regional Tree and Shrub Monitoring

**Project Period**: 1994-1996
**Project Officer**: Daniel Brock
**Project Location**: Alice Springs and Barkly Tableland

**Objectives**: To establish a network of fixed recording sites to monitor the dual problem of excess woody vegetation ("woody weeds"), and diminished tree and shrub populations (often attributed to rabbits). This will provide an estimate
of regional impact and enable the development of a credible regional strategy.

**Background:**
Excess growth of endemic trees and shrubs can lead to a significant decline in the productivity of pastoral land. Shrub invasion is a serious problem in south-west Queensland and western N.S.W. The main problem with high tree and shrub densities are reduced pasture growth, increased mustering costs and lower reproductive rates. Conversely, diminished tree and shrub populations (mainly by rabbits), especially in *Acacia* dominated woodlands can result in reduced soil stability leading to increased soil erosion, less shade for stock and the loss of valuable drought reserve top feed.

Recording of tree and shrub data began in 1981 at fixed recording sites previously established to monitor pasture change. These sites give a preliminary indication of tree and shrub density and cover changes, but do not provide valid regional statistics for planning purposes, because the sampling strategy was not based on existing tree and shrub populations. The current project aims to address this problem using methods previously developed (Bastin 1989, Hodgson 1993).

**Results:**
The project commenced during March, 1994, and is in a preliminary phase. It is funded jointly by the National Landcare Program, and the NT Government.
Current tasks include:
- collection and identification of tree and shrub specimens
- preparation of a tree and shrub literature review
- familiarisation with sampling methods
- development of site selection and sampling methodology
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