

final report

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Weaning management of beef calves – practical guidelines for northern Australian beef producers

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Abstract

The 'Weaning management of beef calves – practical guidelines for northern Australian beef producers' book or simply 'the weaner book' is a compilation of all the research, demonstration and practical knowledge available on weaning and weaner management in northern Australia. Most of this information has been available for some years, but it has not been collated in a single document that is practical and easy to understand. It has been difficult for property owners, managers and their staff to access. The end result of this project is an easy to read guide that has all the available information in one publication. Compiling this information has also highlighted areas where information is limited or non-existent or where available information is not being implemented across the whole industry. This has been evaluated and included in recommendations for further research and or demonstration work.

Executive summary

There is a wealth of information from research findings, on property demonstrations and personal experiences of property owners, managers and advisors on weaning and weaner management of beef calves in northern Australia. Results from most of the research and demonstration work are available in research papers and extension publications such as newsletters and information sheets. Little of the personal experience particularly that of property owners and managers is available other than by personal communication.

The book 'Weaning management of beef calves – practical guidelines for northern Australian beef producers' is an attempt to compile all the available information into one publication for the public.

The book was compiled by a group of experienced staff from Queensland Department of Employment Economic Development and Innovation, Northern Territory Department of Resources and the Western Australia Department of Agriculture and Food. This group was selected for experience and access to information from property owners and managers throughout northern Australia.

The immediate benefit to industry is that there is now one source of information on weaning and weaner management in northern Australia that includes most of the research, demonstration and practical experiences that are available.

Adoption of improved weaning and weaner management methods has short term benefits of reducing breeder mortalities and improving overall breeder herd condition which in turn will result in a reduction in the need for breeder supplementation. The long term benefits include improved reproduction and greater turnoff per breeder unit. Where improved weaner management strategies have been implemented on beef properties, concentrated earlier calving has occurred. Additionally, the adoption of improved weaner management strategies usually results in improved management of the whole herd with significant added benefits to the business.

One down side to implementing these strategies (particularly where weaning calves younger and lighter - down to 100 kg liveweight) is the cost of purchasing feed storage infrastructure and feeding out equipment. On large properties this cost can be significant but has been shown to be more than covered by the benefits accrued from the strategy. There is also a greater need for more precise management of these lighter calves to ensure they grow well.

During the compilation of this book the team identified a number of areas where more knowledge is needed. The most significant of these is the effect of nutritional management on lifetime growth rate from weaning at 100 kg liveweight to turnoff (and particularly from weaning until the break in the season) for a range of markets including live export. The effect of growth rate on carcass characteristics particularly ossification and MSA boning group score needs to be investigated.

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1 Background

Research and demonstration on weaning and weaning management has been carried out for over 50 years. There is also a wealth of research results, and field experience in this area held by advisors to the beef industry and property owners and managers. While much of this information is in written form such as a research reports, demonstration reports, newsletter articles, and 'Tips and Tools' publications a great deal of knowledge is in the form of undocumented experiences of property owners, researchers and industry advisors. Because of this fact, it was difficult, if not impossible, to access and report on all of the available information and experience relating to weaner management in northern Australia.

2 Project objectives

To compile in one book as much of the information on weaning and weaner management in northern Australia as practical so that this information and experience is more readily available to the industry.

3 Methodology

A project group including staff from Queensland Department of Employment Economic Development and Innovation, Northern Territory Department of Resources and the Western Australia Department of Agriculture and Food were selected. The basis for selection of staff was geographic – all areas of northern Australia were to be represented – and experience knowledge and contacts with producers in particular areas.

4 Results and discussion

Regional differences' relating to the practical application of research findings was an internal issue that had to be dealt with by the project team. Integrating these differences into one publication, into a simple format, covering all of northern Australia, was not without its challenge and required multiple meetings and correspondence to reach consensus among the disparate regions. A significant achievement then of the project was that the final output ('the weaner book') represents the best bet practice recommendations for *all* northern Australian beef producing regions.

5 Success in achieving objectives

The project team has achieved the aim of compiling into one publication as much of the information (both research and on property experience) as is practical. The team has also achieved the aim of compiling a list of 'knowledge gaps'. These are in the appendix and have been divided into:

- (a) areas that need detailed research and
- (b) areas that need more on property demonstration to gain more practical experience and better uptake of information by industry.

6 Impact on meat and livestock industry – Now and in five years time

While we have incorporated as much research and practical experience as possible, it was not possible to cover every eventuality a producer might encounter. Thus, the information provided in the book must be considered with one's practical experience relevant to a specific area.

Improving weaning and weaner management cannot be done in isolation from managing the rest of the breeder herd. Practical experience has shown that improving weaning and weaner management results in improved management of the entire breeder herd. Yet, it can be difficult to attribute overall improved herd performance to any single aspect of management.

Improving weaning and weaner management has a number of short and long term benefits.

Short term

- Reduced breeder mortality
- Decrease in supplementary feeding costs for the breeder herd
- Improved breeder condition

Long term

- Increased conception and therefore weaning rates
- More concentrated calving in continuously mated herds
- More income from sale of females

Caution

Where a strategy to wean calves younger and lighter is implemented considerable costs can be incurred in the purchase and setting up of feed storage, feeding out equipment and feed troughs. This strategy also requires a high standard of management of the younger and lighter calves and is often more labour intensive. In situations where the dietary requirements from native pastures is inadequate and if a high standard of management and appropriate supplementation is not implemented, young weaners do poorly and significant losses can occur. Coccidiosis is common in poorly managed young weaners.

7 Conclusions and recommendations

In compiling this book the project team has identified areas where further research and development is required.

Information and knowledge gaps for weaning and weaner management in northern Australia

Research

1. Impact of growth rate (from maintenance upwards) from weaning to slaughter with particular emphasis on the period from weaning until the break in the season on:
 - a. subsequent growth to slaughter
 - b. lifetime reproductive performance
 - c. carcass traits particularly ossification and MSA grading
 - d. weight and age at puberty.
 2. The production advantage of NPN supplementation of early weaners (100 to 180 kg) with varying diets (as estimated from NIRS). There is a lot of work on true protein based supplements but not a lot with NPN supplements.
 3. The optimum supplementation level (ie grams of urea per head) with varying diets. The early work was done at Swans with Black Speargrass as the base diet, which had a limited digestibility. With more digestible fodder (i.e. better quality native pastures) there may be an economic benefit with higher level of urea than suggested from the Swans data.
 4. Need to establish minimum growth targets to optimise future productivity of different classes of weaners for a range of markets including live export.
 5. Practical strategies to monitor skeletal growth in juvenile cattle.
 6. Management of skeletal growth and its impact on achieving target weights in steers and heifers.
- NB A greater benefit would come if the birth date and/or weight of individual animals used in any experiment was known so that growth from birth to turnoff and actual age at turnoff could be calculated. The age of any group of cattle particularly those from commercial properties could vary by 6 to 12 months which will have a major influence on carcass traits such as ossification.
7. Role of gene marker or similar technology to identify individuals at weaning that are most likely to respond to management inputs to meet future target performance. The concept here is to be able to identify individuals that have the potential to meet different grading requirements such as MSA, have a younger age and weight at puberty, etc. Identified groups could be drafted at weaning into their potential performance groups for more efficient management thus potentially improving business profitability and performance.
 8. Demonstrating the value of NIRS as a tool to predict diet quality selected by weaners and using this information to determine supplementary feeding requirements to achieve a range of growth rates.

9. Foetal programming effects due to under-nutrition of cows in early-mid pregnancy on progeny growth, reproductive performance and carcass traits.
10. Health - Management of internal parasites in weaners and cost effectiveness of treating for internal parasites.

Demonstration

The need, as demonstrated by the work in 1 above for good management of weaners from the day of weaning until the break in the season.

Some specific constraints/opportunities are:

- Insufficient weaner paddocks
- Wet season spelling of weaner paddocks
- Separate weaner paddock for second round weaners
- Value of improved pasture/inclusion of legumes in weaner paddocks

Improving feeding systems:

- Guidelines for trough spacing for lick, protein meal, fortified molasses
- Optimal mob sizes for particular weaner classes and supplements
- Supplement delivery equipment to reduce labour requirements

Recommendation

MLA talk to Dr Steve Petty with a view to having the report on his weaner management at Flora Valley in the 1990's published.

General comments

In some cases the recommended research and demonstration has been done, but using animals over 200 kg liveweight at weaning, temperate breeds and with minimum growth rates of about 0.4 kg per day. We recommend that the research and demonstration be done in northern Australia using weaners of tropical breeds from 100 kg liveweight up to 200 kg liveweight with minimum growth rates from 0.2 kg per day.

The project group realise that animal welfare issues may prevent minimum daily gain targets of less than 0.4 kg being included in a research project. Therefore, information on performance of animals with low growth rate may be able to be achieved by assessing the daily gain of individual animals in a large group where the mean daily gain target may be 0.4 kg per day or higher. In practice, however, the growth potential for animals that grow slowly from weaning to the break in the season would likely be from animals with a low genetic ability to grow, rather than from animals with a higher genetic ability to grow but on a low plain of nutrition.

8 Bibliography

References relating to weaning and weaner management in northern Australia.
Compiled by Lauren Williams 7/10/11

Books

Hasker PJS (2000) 'Beef cattle performance in northern Australia: a summary of recent research.' (Department of Primary Industries, Queensland, Brisbane.)

Newman R (2007) 'A guide to best practice husbandry in beef cattle - branding, castrating and dehorning.' (Meat and Livestock Australia, Limited.)

Conference proceedings

Coates DB, Bean KG Post-weaning growth rates of Belmont Red and Hereford steers. In 'Proceedings of the Australian Society of Animal Production', 1978, p. 218.

Eggington AR, Corbet NJ, McCosker TH Nutritional factors affecting cattle weaner growth and survival in the Darwin district of the N.T. In 'Proceedings of the Australian Society of Animal Production', 1986, pp. 195-198.

Eggington AR, McCosker TH, Bainbridge MH Valbazen (albendazole) treatment of Brahman cross weaners in the top end of the Northern Territory. In 'Proceedings of the Australian Society of Animal Production (Animal Production in Australia)', 1984, p. 674.

Fell LR, Walker KH, Reddacliff LA, Davies L, Vallance HJ, House JR, Wilson SC Effects of yard weaning and pre-feedlot vaccination on feedlot performance of Bos taurus steers. In 'Proceedings of the Australian Society of Animal Production (Animal Production in Australia)', 1998, pp. 173-176.

Fordyce G, D'Occhio MJ, Cooper NJ, Kendall IE, O'Leary BM First oestrus in Brahman cross heifers in the dry tropics and the influence of supplementation. In 'Proceedings of Reproduction in Tropical Environments, Satellite meeting of the 13th International Congress on Animal Reproduction. Tropical Beef Centre, Rockhampton, Australia', 1996.

Fordyce G, Holroyd RG, James TA, Reid DJ The effect of post-weaning growth on the fertility of Brahman cross heifers. In 'Proceedings of the Australian Society of Animal Production', 1988, p. 396.

Goddard ME, Entwistle KW, Dixon R Variables affecting pregnancy rate in Bos indicus cross cows. In 'Proceedings of the Australian Society of Animal Production', 1980, pp. 65-67.

Holroyd RG, Petherick JC The impact of weaning and processing on the health and performance of beef heifers. In 'Hemsworth PH, Spinka M and Kostal L (eds) Proceedings of the 31st Congress of the International Society for Applied Ethology Research Institute of Animal Production', 1997, Prague, Czech Republic, p. 159.

Holroyd RG, Smith PC, Thompson PJM, Toleman MA Reproductive performance of 50% Bos indicus cattle grazing the Mitchell grasslands of north Queensland. In 'Proceedings of the Australian Rangeland Society', 1988, pp. 49-53.

McCosker TH, Eggington AR, Doyle FW Observations on post weaning performance of Braham cross animals in the Darwin district of the Northern Territory. In 'Proceedings of the Australian Society of Animal Production', 1984, pp. 452-455.

McLennan SR, Hirst DJ, O'Rourke PK Effect of molasses and nitrogen supplements on the liveweight performance of weaner heifers grazing tropical pastures. In 'Proceedings of the Australian Society of Animal Production', 1984, p. 718.

Oddy VH The impact of science developed in the Beef CRCs on feeding and management practices in the Australian beef industry. In 'Proceedings Australian Beef - the Leader! Conference Beef CRC, Armidale, March', 2006, pp. 137-140.

O'Rourke PK Replication for survival feeding experiments in pens with weaner beef cattle. In 'Proceedings of the Australian Society of Animal Production', 1984, pp. 61-63.

Petherick C, Holroyd RG, Doogan VJ, Cooper NJ Timing of weaning and processing: effects on liveweight changes of weaner cattle. In 'Proceedings of the Australian Society of Animal Production', 1998, p. 320.

Petty S, Ryan W, Pratchett D, Hadden D The impact of once a year weaning of calves to 60 kg on breeder fertility and mortality in the Kimberley-preliminary results. In 'Proceedings of the Australian Society of Animal Production', 1994, p. 340.

Schlink AC, Gibson DS, Liang ZJ, Dixon R Calf management strategies and reproductive performance in a northern Australian cattle herd. In 'Proceedings of the Australian Society of Animal Production', 1988, pp. 326-329.

Schlink AC, Houston EM, Day A, Entwistle KW Supplementation of *Bos indicus* cross calves grazing wet season tropical pastures. In 'Proceedings of the Australian Society of Animal Production', 1994, pp. 104-107.

Schlink AC, Houston EM, Entwistle KW Impact of long term early weaning on the productivity of *Bos indicus* cross cows. In 'Proceedings of the Australian Society of Animal Production', 1994, p. 339.

Seifert GW, Corlis PL, Rudder TH The influence of dam age on weight for age of steers at weaning, and after weaning. In 'Proceedings of the Australian Society of Animal Production', 1980, pp. 373-376.

Sullivan RM Weaner supplementation and management in the Victoria River District of the Northern Territory. In 'Proceedings of the Australian Society of Animal Production', 1988, pp. 342-346.

Tyler R, Fordyce G Assessing the survival risk of cows prior to drought. In 'Proceedings of the Australian Society of Animal Production', 1988, p. 478.

Winks L, Alexander GI, Lynch D Urea supplements for grazing beef weaners. In 'Proceedings of the Australian Society of Animal Production', 1970, pp. 34-38.

Winks L, Laing AR Urea, phosphorus and molasses supplements for grazing beef weaners. In 'Proceedings of the Australian Society of Animal Production', 1972, pp. 253-257

Winks L, Laing AR, Stokoe J Level of urea for grazing yearling cattle during the dry season in tropical Queensland. In 'Proceedings of the Australian Society of Animal Production', 1972, pp. 258-261

Industry articles

Bertram J (2003) Early weaning - practical experience. In 'Beeftalk. Vol. 15'. pp. 22. (Department of Primary Industries, Queensland.)

Dixon RM, Petherick JC (1995) Trainer weaner calves to eat dry lick supplements. In 'Northern Muster. Vol. 52'. pp. 14-15. (Department of Primary Industries, Queensland.)

Laing AR (2006) A guide to the amounts of various types of supplements needed to maintain moderate growth rates of weaners. In 'Northern Muster. Vol. 12'. pp. 32. (Department of Primary Industries, Queensland.)

Laing AR (2006) Lean wet season may need earlier attention to weaning. In 'Northern Muster. Vol. 12'. pp. 33. (Department of Primary Industries, Queensland.)

Laing AR (2007) Molasses based supplements for weaners. In 'Northern Muster. Vol. 17'. pp. 27. (Department of Primary Industries, Queensland.)

Laing AR (2008) Dehorning best practice. In 'Northern Muster. Vol. 20'. pp. 12-13. (Queensland Department of Primary Industries, Queensland.)

Laing AR (2008) Post weaning diarrhoea. In 'Northern Muster. Vol. 19'. pp. 12. (Queensland Department of Primary Industries.)

McConnel C (2008) Weaning and educating calves. In 'Beeftalk. Vol. 25'. pp. 4. (Department of Primary Industries, Queensland.)

Nieth G (2007) Manage breeding cows to improve weaning rates. In 'Beeftalk. Vol. 23'. pp. 2. (Department of Primary Industries, Queensland.)

Pratchett D (1987) Is weaning worthwhile? In *Ord Research Station, Regeneration Field Day Handout, September 1987.*

Rolfe J, English B, Matthews R (2011) Boost your profits with good weaner care. In 'Northern Muster. Vol. 27'. pp. 18-20. (Department of Employment, Economic Development and Innovation, Queensland.)

Tyler R (2009) Post-weaning diarrhoea. In 'Beeftalk. Vol. 27'. pp. 4. (Department of Primary Industries, Queensland.)

Tyler R (2010) Weaning - the cheapest supplement. In 'Beeftalk. Vol. 29'. pp. 6. (Department of Employment, Economic Development and Innovation.)

Tyler R (2011) Controlling coccidiosis. In 'Beeftalk. Vol. 31'. pp. 2. (Department of Employment, Economic Development and Innovation.)

Industry reports

Corlis PL, Taylor WJ (1979) Anthelmintic response trial - Wirranda, via Moura, BIL-CH524. Circulated Trial Report 79/9, Beef Cattle Husbandry Branch, Department of Primary Industries, Queensland.

Dixon R (1998 unpublished) 3. Task 1. Experimentation on the effects of urea-based supplements on breeder herd productivity. Improving Cost-effectiveness of Supplementation Systems for Breeder Herds in Northern Australia, Project DAQ.098, Final Report, Department of Primary Industries, Queensland.

Dixon R (1998 unpublished) Appendix 3, Milestone Report 3, Collation of recent information on productivity and use of supplements for breeders in the marginal and harsh regions of northern Australia. Improving Cost-effectiveness of Supplementation Systems for Breeder Herds in Northern Australia, Project DAQ.098, Final Report, Department of Primary Industries, Queensland.

Dixon R, Fry P, White A, Petherick C (1997 unpublished) Effect of early exposure as weaners on subsequent intake of dry lick supplement by 3-year-old-steers-SWN-B842. Swans Lagoon Research Station Annual Report. Department of Primary Industries, Queensland.

Dixon RM (1998) Improving cost-effectiveness of supplementation systems for breeder herds in northern Australia. Final Report, Project DAQ.098, Meat and Livestock Australia, Sydney.

Fordyce G (1994 unpublished) Task reports. Heifer fertility. Long-term effects of early weaning of heifers on growth and fertility. Developing Cost-effective Strategies for Improved Fertility in Bos indicus Cross Cattle. Final Report Project DAQ.062/UNQ.009, Department of Primary Industries, Queensland: James Cook University: Meat Research Corporation.

Fordyce G (1994 unpublished) Task reports. Heifer fertility. The influence of dry season growth and supplementation of prepubetal Brahman cross heifers on their subsequent fertility. Developing Cost-effective Strategies for Improved Fertility in Bos indicus Cross Cattle. Final Report Project DAQ.062/UNQ.009, Department of Primary Industries, Queensland: James Cook University: Meat Research Corporation.

Holroyd RG, Fordyce G (1990) A study of factors affecting production efficiency of Bos indicus cattle in north Queensland. Project Report DAQ.44, Australian Meat and Livestock Research and Development Corporation, Sydney.

Holroyd RG, O'Rourke PK (1989) Collation of biological data on beef cattle production in north Australia. Project Report, Australian Meat and Livestock Research and Development Corporation, Sydney.

Lindsay JA, Cooper NJ, Gelling BA (1995 unpublished) Comparison of grain and molasses for radical weaners-SWN-B802. Swans Lagoon Research Station Annual Report. Department of Primary Industries, Queensland. 1993 pp. 104-106, 1994 pp. 108-110, 1995 pp. 113-115.

Lindsay JA, Gelling BA, Cooper NJ, Batterham I, Lloyd A (1997 unpublished) Growth recovery of early weaned calves-SWN-B812. Swans Lagoon Research Station Annual Report. Department of Primary Industries, Queensland. 1994 pp. 111-114, 1995 pp. 117-121, 1996 pp. 124-135, 1997 pp. 75-85.

Lindsay JA, White A, Cooper NJ (1997 unpublished) Growing out early weaned calves-SWN-B838. Swans Lagoon Research Station Annual Report. Department of Primary Industries, Queensland. pp. 86-88.

Lindsay JA, White A, Hirst DJ (1997 unpublished) Growing out early weaned calves-SWN-B844. Swans Lagoon Research Station Annual Report. Department of Primary Industries, Queensland. pp. 89-90.

McCosker TH, Eggington AR (1986) Beef cattle production and herd dynamics in the monsoon tallgrass region of north Australia - Case studies of several management and nutrition regimes. In 'Technical Bulletin. Vol. 93'. (Northern Territory Department of Primary Production, Darwin)

Winks L (1975) Weaner supplementation trial, 1972 dry season draft. Circulated Trial Report 75/4. Beef Cattle Husbandry Branch, Department of Primary Industries, Queensland.

Refereed Journal publications

Addison KB, Cameron DG, Blight GW (1984) Biuret, sorghum and cottonseed meal as supplements for weaner cattle grazing native pastures in subcoastal south-east Queensland. *Tropical Grasslands* 18, 113-120.

Addison KB, Cameron DG, Blight GW (1984) Effects of leucaena and peanut meal supplement fed to steers grazing native pasture in sub-coastal south-east Queensland. *Tropical Grasslands* 18, 121-130.

Alexander GI, Beattie AW (1968) Studies on factors in beef cattle production in a subtropical environment. 3. Growth from weaning to yearling. *Queensland Journal of Agricultural and Animal Sciences* 25, 7-17.

Alexander GI, Beattie AW, Sutherland DN (1964) Studies on factors in beef cattle production in a subtropical environment. 2. Growth to weaning. *Queensland Journal of Agricultural and Animal Sciences* 21, 25-32.

Arthur BA, Mayer BG (1975) More beef through early weaning. *Queensland Agricultural Journal* 101(2), 217-221.

Burns BM, Fordyce G, Holroyd RG (2010) A review of factors that impact on the capacity of beef cattle females to conceive, maintain a pregnancy and wean a calf-Implications for reproductive efficiency in northern Australia. *Animal Reproduction Science* 122(1-2), 1-22.

Churchward RE (1965) Some observations on reproductive performance of beef cattle in north west Queensland. *Australian Veterinary Journal* 41, 352-355.

Daly JJ (1971) Beef breeder study in the north-west. *Queensland Agricultural Journal* 97, 93-100.

Dixon RM (1999) Effects of addition of urea to a low nitrogen diet on the rumen digestion of a range of roughages. *Australian Journal of Agricultural Research* 50(6), 1091-1097.

Dixon RM, Playford C, Coates DB (2011) Nutrition of beef breeder cows in the dry tropics. 1. Effects of nitrogen supplementation and weaning on breeder performance. *Animal Production Science* 51(6), 515-528.

Dixon RM, Playford C, Coates DB (2011) Nutrition of beef breeder cows in the dry tropics. 2. Effects of time of weaning and diet quality on breeder performance. *Animal Production Science* 51(6), 529-540.

Dixon RM, White A, Fry P, Petherick JC (2003) Effects of supplement type and previous experience on variability in intake of supplements by heifers. *Australian Journal of Agricultural Research* 54(6), 529-540.

Donaldson LE (1971) Investigations into the fertility of Brahman crossbred female cattle in Queensland. *Australian Veterinary Journal* 47(6), 264-267.

Doogan VJ, Fordyce G, Shepherd RK, James TA, Holroyd RG (1991) The relationships between liveweight, growth from weaning to mating and conception rate of *Bos indicus* cross heifers in the dry tropics of north Queensland. *Australian Journal of Experimental Agriculture* 31(2), 139-144.

Ernst AJ, Limpus JF, O'Rourke PK, Loxton ID (1976) Effect of biuret, grain and mineral mixture on the intake and liveweight performance of weaner steers. *Queensland Journal of Agricultural and Animal Sciences* 33(2), 213-221.

Fordyce G, Loxton ID, Holroyd RG, Tyler R, Howitt CJ, Mayer RJ (1993) The performance of Brahman-Shorthorn and Sahiwal-Shorthorn beef cattle in the dry tropics of northern Queensland. 4. Post-weaning growth and carcass traits. *Australian Journal of Experimental Agriculture* 33, 531-539.

Fordyce G, Tyler R, Anderson VJ (1990) Effect of reproductive status, body condition and age of *Bos indicus* cross cows early in a drought on survival and subsequent reproductive performance. *Australian Journal of Experimental Agriculture* 30(3), 315-322.

Foster AH, Blight GW (1984) Liveweight response of cattle grazing native pasture in south-east Queensland when supplemented with urea molasses in winter and spring. *Tropical Grasslands* 18, 131-137.

Graham TWG, Wood SJ, Knight JL, Blight GW (1983) Urea and molasses as a winter supplement for weaner steers grazing improved pastures in central Queensland. *Tropical Grasslands* 17, 11-20.

Holroyd RG (1987) Foetal and calf wastage in *Bos indicus* cross beef genotypes. *Australian Veterinary Journal* 64(5), 133-7.

Holroyd RG, Mason GWJ, Loxton ID, Knights PT, O'Rourke PK (1988) Effects of weaning and supplementation on liveweight, survival and reproductive performance of Brahman cross cattle and on growth rate of their progeny to weaning. *Australian Journal of Experimental Agriculture* 28, 11-20.

Holroyd RG, O'Rourke PK, Allan PJ (1979) Reproductive performance of Shorthorn and Brahman crossbred cows in the dry tropics of north Queensland. *Australian Journal of Experimental Agriculture and Animal Husbandry* 19(98), 276-282.

Holroyd RG, O'Rourke PK, Tyler R, Stephenson HP, Mason GWJ, Schroter KL (1990) Effects of different weaning strategies on postweaning growth rate, mortality and fertility of *Bos indicus* cross cattle. *Australian Journal of Experimental Agriculture* 30, 1-6.

Lampkin GH, Kennedy JF (1965) Some observations on reproduction, weight change under lactation stress and the mothering ability of British and zebu cattle in the tropics. *Journal of Agricultural Science* 64(3), 407-12.

Matthews RA, Fordyce G, Poppi DP (2008) Nutritional management of skeletal bone growth in cattle in the dry tropics. *Animal Production in Australia* 27, 57.

McLennan SR, Dunster PJ, O'Rourke PK, Murphy GM (1981) Comparison of dry season urea supplements containing salt, sulfur or molasses for steers grazing native pasture in the dry tropics of north Queensland. *Australian Journal of Experimental Agriculture and Animal Husbandry* 21, 457-463.

McLennan SR, Hirst DJ, Shepherd RK, McGuigan KR (1991) A comparison of various methods of feeding supplements of urea, sulfur and molasses to weaner heifers during the dry season in northern Queensland. *Australian Journal of Experimental Agriculture* 31(2), 153-158.

Petherick JC, Fry P, Mayer RJ, Dixon RM (1996) Effects of lick-block siting on supplement intake and behaviour of cattle. *Animal Production in Australia* 22, 291.

Pratchett D, Young S (1989) Weaning Kimberly cattle pays off. *Journal of Agriculture, Western Australia* 30(2), 56-57.

Round PJ, Mellor W, Hibberd M (1982) The effect of age and season of introduction on the liveweight performance of steers in the wet tropics. *Tropical Animal Production* 7, 43-49.

Rudder TH, Seifert GW, Maynard PJ (1976) Factors affecting reproduction rates in a commercial Brahman crossbred herd. *Australian Journal of Experimental Agriculture and Animal Husbandry* 16(82), 623-629.

Seifert GW, Rudder TH, Lapworth JW (1974) Factors affecting weaning weight of beef cattle in a tropical environment. *Australian Journal of Experimental Agriculture and Animal Husbandry* 14, 277-280.

Strachan RT, Peart WJ, Coleman RG, O'Rourke PK (1980) Post-weaning growth and carcass characteristics of Chianina, Brahman and Hereford cross, and Hereford steers in southern Queensland. *Australian Journal of Experimental Agriculture and Animal Husbandry* 20(104), 257-384.

Sullivan RM, O'Rourke PK (1997) A comparison of once- and twice-yearly weaning of an extensive herd in northern Australia .1. Cow liveweights, mortalities and fertility. *Australian Journal of Experimental Agriculture* 37(3), 279-286.

Sullivan RM, O'Rourke PK, Neale JA (1997) A comparison of once- and twice-yearly weaning of an extensive herd in northern Australia .2. Progeny growth and heifer productivity. *Australian Journal of Experimental Agriculture* 37(3), 287-293.

Sullivan RM, O'Rourke PK, Robertson DJ, Cooke D (1992) Effects of once-yearly weaning on some aspects of herd productivity in an extensive herd in the semiarid tropics of northern Australia. *Australian Journal of Experimental Agriculture* 32(2), 149-156.

Tierney TJ, Taylor WJ, Bean KG (1985) Some factors influencing the growth of young beef cattle grazing improved pastures in south east Queensland. *Tropical Grasslands* 19, 109-115.

Tomkins NW, Harper GS, Bruce HL, Hunter RA (2006) Effect of different post-weaning growth paths on long-term weight gain, carcass characteristics and eating quality of beef cattle. *Australian Journal of Experimental Agriculture* 46(12), 1571-1578.

Walker KH, Fell LR, Reddacliff LA, Kilgour RJ, House JR, Wilson SC, Nicholls PJ (2007) Effects of yard weaning and training on the behavioural adaptation of cattle to a feedlot. *Livestock Science* 106(2-3), 210-217.

Winks L, Laing AR, O'Rourke PK, Wright GS (1979) Factors affecting response to urea-molasses supplements by yearling cattle in tropical Queensland. *Australian Journal of Experimental Agriculture and Animal Husbandry* 19, 522-529.

Winks L, Laing AR, Wright G, Stokoe J (1976) The effect of nitrogen, phosphorus and molasses supplements on the performance of weaner cattle during the dry season in north Queensland. *Journal of the Australian Institute of Agricultural Science* 42, 246-251.

Winks L, Laing AR, Wright GS, Stokoe J (1976) Effects of nitrogen, phosphorous and molasses on the performance of weaner cattle during the dry season in north Queensland. *Journal of the Australian Institute of Agricultural Science* 42, 246-251.

Winks L, O'Rourke PK, McLennan SR (1982) Liveweight of grazing steers supplemented with molasses, urea and sulfur in northern Queensland. *Australian Journal of Experimental Agriculture and Animal Husbandry* 22, 252-257.

Winks L, O'Rourke PK, Smith PC (1978) Performance of F1 Brahman X Shorthorn and F1 Sahiwal X Shorthorn cattle from weaning to slaughter in north Queensland. *Australian Journal of Experimental Agriculture and Animal Husbandry* 18(93), 500-504.

Winks L, Venamore PC, James TA, O'Grady P, O'Rourke PK (1980) Performance of steers grazing a tropical grass-legume pasture on the Atherton Tableland. *Queensland Journal of Agricultural and Animal Sciences* 37, 199-206.

Winks L, Walker RW, O'Rourke PK, Loxton ID, Holmes AE, Shaw KA (1983) Molasses supplementation of steers grazing a tropical grass-legume pasture in North Queensland. *Tropical Grasslands* 17(2), 64-76.

Winks L, Wright GS, Wighton PA (1980) Fortified molasses for steers grazing native pasture in north Queensland. *Queensland Journal of Agricultural and Animal Sciences* 37, 189-197.

Winks LW (1984) Cattle growth in the dry tropics of Australia. *Australian Meat Research Committee Review*(45).

Winter WH (1987) Using fire and supplements to improve cattle production from monsoon tallgrass pastures. *Tropical Grasslands* 21, 71-81.

Non-refereed publications

Gulbransen B, Robertson RF (1995 unpublished) Assessing diets for early-weaned calves. In Holroyd R and Hasker P (eds), *Nutritional and Managerial Strategies to Increase Liveweight Gain and Improve Product Quality in Steers, Cull Cows and Heifers in Queensland Beef Herds. The Experimental Collection from Project DAQ.065*, pp. 147-149. Department of Primary Industries, Queensland.

Lindsay JA, Cox RD, Gelling BA, Kendall IE, Dyer RM (1995 unpublished) Growing out weaners from two months of age-SWN-CH742. In Holroyd R and Hasker P (eds), *Nutritional and Managerial Strategies to Increase Liveweight Gain and Improve Product Quality in Steers, Cull Cows and Heifers in Queensland Beef Herds. The Experimental Collection from Project DAQ.065*, pp. 138-139. Department of Primary Industries, Queensland.

Lindsay JA, Dyer RM, Cox RD, Gelling BA (1995 unpublished) Reducing post weaning stress and growing out from 70 kg at weaning-SWN-CH747. In Holroyd R and Hasker P (eds), *Nutritional and Managerial Strategies to Increase Liveweight Gain and Improve Product Quality in Steers, Cull Cows and Heifers in Queensland Beef Herds. The Experimental Collection from Project DAQ.065*, pp. 150-152. Department of Primary Industries, Queensland.

Lindsay JA, Dyer RM, Gelling BA (1995 unpublished) Comparison of grain and molasses for radical weaners-SWN-CH-B802. In Holroyd R and Hasker P (eds), *Nutritional and Managerial Strategies to Increase Liveweight Gain and Improve Product Quality in Steers, Cull Cows and Heifers in Queensland Beef Herds. The Experimental Collection from Project DAQ.065*, pp. 161-162. Department of Primary Industries, Queensland.

O'Rourke PK, Winks L, Kelly AM (1992 unpublished) *North Australia Beef Producer Survey 1990*. Department of Primary Industries, Queensland & Meat Research Corporation.

Post-graduate degree publications

Andrews LG (1976) Reproductive performance of beef cattle in the Northern Territory. M.Sc. Thesis, James Cook University of North Queensland, Townsville.

Holroyd RG (1977) Reproductive performance of beef cattle in northern Queensland. M.Sc. Thesis, James Cook University of North Queensland, Townsville.

Holroyd RG (1985) Aspects of reproduction in *Bos indicus* genotypes. Ph.D. Thesis, James Cook University of North Queensland, Townsville.

Producer Demonstration Site reports

Burns BM (1996 unpublished) Radical weaning trial, 'Hazelwood', Richmond. In *Producer Demonstration Sites Final Report, August, Part 4, DAQ.M001*. pp. 111-114. Department of Primary Industries, Queensland.

Burns BM (1996 unpublished) Radical weaning trial, 'Lonsdale', Richmond. In *Producer Demonstration Sites Final Report, August, Part 4, DAQ.M001*. pp. 117-121. Department of Primary Industries, Queensland.

Cheffins R (1996 unpublished) Overcoming weaner wilt. In *Producer Demonstration Sites Final Report, August, Part 4, DAQ.M001*. pp. 384-386. Department of Primary Industries, Queensland.

Elphinstone G (1996 unpublished) Weaner supplementation. In *Producer Demonstration Sites Final Report, August, Part 4, DAQ.M001*. pp. 413-415. Department of Primary Industries, Queensland.

Hill F (1996 unpublished) Early weaning demonstration. In *Producer Demonstration Sites Final Report, August, Part 4, DAQ.M001*. pp. 122-126. Department of Primary Industries, Queensland.

Smith P (1996 unpublished) Early weaning demonstration, 'Blackbraes', Hughenden. In Producer Demonstration Sites Final Report, August, Part 4, DAQ.M001. pp. 74-76. Department of Primary Industries, Queensland.

Sullivan MT (1996 unpublished) Improving liveweight gains and targeting markets. In Producer Demonstration Sites Final Report, August, Part 4, DAQ.M001. pp. 336-339. Department of Primary Industries, Queensland.

Sullivan MT (1996 unpublished) Millungera breeder management demonstration. In 'Producer Demonstration Sites Final Report, August, Part 4, DAQ.M001. pp. 127-139. Department of Primary Industries, Queensland.

Tyler R (1996 unpublished) Early weaning of beef cattle. In 'Producer Demonstration Sites Final Report, August, Part 4, DAQ.M001. pp. 148-151. Department of Primary Industries, Queensland.

Webber RJ (1996 unpublished) Early weaning demonstration, 'Blancourt', Richmond. In 'Producer Demonstration Sites Final Report, August, Part 4, DAQ.M001. pp. 140-143. Department of Primary Industries, Queensland.

Webber RJ (1996 unpublished) Forest Home weaner nutrition demonstration. In 'Producer Demonstration Sites Final Report, August, Part 4, DAQ.M001. pp. 227-230. Department of Primary Industries, Queensland.