



Australian Government

**Rural Industries Research and
Development Corporation**

Crocodile Farming Research:

**On-farm research of pelleted
feed for crocodiles**

A report for the Rural Industries Research and
Development Corporation

by SKJ Peucker and RH Jack

February 2006

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Foreword

This project forms part of a broader based crocodile research and development program that has been on-going since 1993. The program aims to improve the profitability and sustainability of commercial crocodile production in Australia. The primary objective of this project titled “On-farm research of pelleted feed for crocodiles” was to evaluate manufactured feed for crocodiles grown under commercial conditions.

Crocodiles are traditionally fed on diets of raw meat, poultry or poultry by-products such as heads and necks. Fresh meat is high in water content, requires storage using large freezers which can be expensive to operate. Transportation costs are becoming increasingly expensive and handling of such feed can be difficult. Food safety is an important consideration for industry with sale of crocodile meat taking on an important role in terms of farm income, and manufactured feed reduces the risk of bacterial contamination.

Stakeholder involvement was considered an important component of the project. To this end the establishment of the Crocodile Nutrition Group (CNG) and the addition of the “on farm research” project further utilised industries knowledge and experience. In a co-operative industry approach, farms in the Northern Territory and Queensland participated in trialling the best research diets on their farms. Feed was formulated and manufactured by the Department of Primary Industries and Fisheries at Townsville. On farm research can be difficult; farms have to allocate resources, time and labour. It can be a fine line between allocating pens for research and commercial needs. During this project the Australian crocodile industry have been willing and enthusiastic partners.

Good results have been achieved with manufactured feed under research conditions. These results have at this stage not been reproduced under commercial conditions. There are a number of reasons why this has not happened on commercial farms. Apart from problems associated with acceptability, other management issues such as disease outbreaks, the availability of pen space and management mishap have all contributed to why trials ceased. So progress under commercial conditions has not been as rapid as first anticipated.

This project was funded from RIRDC core funds which are provided by the Australian Government.

This report is an addition to RIRDC’s diverse range of over 1500 research publications. It forms part of our New Animal Product R&D sub-program which aims to accelerate the development of viable new animal industries

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Peter O’Brien

Managing Director

Rural Industries Research and Development Corporation

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Several individuals have made a special contribution to the on farm research project through there participation and support.

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Executive Summary

The Report

The report describes progress in the development of formulating and testing manufactured feeds for raising crocodiles in intensified husbandry environments

The Target

Rural Industries Research and Development Corporation (RIRDC) and the Department of Primary Industries and Fisheries (DPI&F) have a contractual agreement designed to assist the development of the Australian crocodile industry. Both organisations share the goal of a profitable and sustainable commercial industry, which will achieve its objectives through improved technology.

The primary beneficiaries of this research program will be Australian commercial crocodile producers. There will also be a flow on effect to tanners, processors, retailers and ultimately consumers by having a guaranteed supply of quality product available to them.

Background

Crocodile farming is described as an emerging industry and as such has less experience with commercial intensive livestock principles than the more established industries such as pigs and poultry. Despite this comparative lack of intensive livestock skills, the crocodile industry is making rapid progress in closing the gap. Crocodile farming is moving from extensive outdoor practices, modelled on wild habitat observations which are much influenced by climatic conditions, to intensive environmentally controlled housing which is being used for hatchlings and in some cases for grower animals on commercial farms. Several producers are going a step further and creating individual pens for grower animals to prevent fighting and subsequent skin damage, thus placing a more valuable product on the market which leads to higher returns on investment. Most producers have expanded their operations considerably over the last two to three years. Demand for skins and meat continues to increase, with demand outstripping supply.

Manufactured feed (pellets) was first identified as an industry priority at an industry meeting in 1995. Grower animals raised on diets consisting of poultry by-products tend to produce over fat square shaped skins. From the tanners and manufacturer perspective they require a narrower rectangle shaped skin because they can cut more product from skins with this configuration. Manufactured feed offers the opportunity to manipulate diets in order to meet produce animals with skins that client demands.

Research has already established that crocodiles will eat manufactured diets containing no raw meat and that growth rates of 16grams/crocodile/day are being achieved. Also that manufactured feed offers a 2.4:1 ratio over offal diets on a dry matter basis. Recent work has shown that a slow weaning process offers the best opportunity of gaining acceptability by young crocodiles and that acceptability appears to be linked to the animals live weight rather than age. (see RIRDC publication No 05/152 titled *Crocodile Farming Research: Hatching to Harvest.*)

Profit margins vary between farms depending on a number of inputs such as labour, animal costs, feed and mortalities. The cost of feeding animals represents a significant proportion of the cost of production. It is anticipated that pelleted feed has the potential to reduce feed costs by as much as 20-40 % with the production of a commercially available steam extruded pellet with 10% moisture content.

Other advantages in using manufactured feed over meat diets are in transportation, storage and handling costs. Manufactured feed will provide better nutrition and nutrient supply to crocodiles while also reducing the cost of diets. In recent times drought conditions across much of Australia combined with increasing fuel prices have had a two fold effect on feed. The drought is placing pressure on the availability of traditional food such as kangaroo meat and fuel prices have pushed up the freight component of transporting feed to farms thus affecting profitability. These two factors add to the necessity for the manufactured feed research to continue.

Aims and Objectives

Initiate on-farm feeding trials using the most successful pellet diet from the research program.

Implement use of an environmentally friendly and consumer acceptable crocodile feed on farms.

Establish the feeding and growth response for farmed crocodiles on trial (pelleted) diets- the trials will cover hatchlings, juveniles and growers >2 years old.

Purchase of a Bioelectrical Impedance Analyser (BIA) machine or similar equipment so that growth response measurements will be standardised across farms.

Promote growth of lean crocodiles to meet market demand.

Compare on-farm pellet feed costs with traditional diets of chicken heads and kangaroo meat.

Methods

This report covers the trialling of manufactured feed under commercial conditions from 2003-2005. Several farms in the Northern Territory and Queensland have participated in these trials. Pellet acceptability on farms to date has not been successful to the stage where animals are fed solely manufactured feed. There are a number of reasons for this including acceptability of the pellet itself other factors such as disease outbreaks and other management issues have played apart in the total non acceptance of manufactured feed during these trials.

Results

Crocodiles have been taken through to harvest size fed solely on manufactured feed. This has occurred only when animals have been returned from the Department's facility to a commercial farm. Upon return the animals have continued to be fed manufactured feed. Small groups of animals have been deemed suitable for harvesting over trial period. It is worth noting in this instance that having only one pen available for research lead to some animals growing quite well and other's performing poorly. Under normal practices, the larger animals would have been graded off to another pen of similar size animals thus allowing the smaller animals to gain better access to feed.

At harvesting it was observed by processors that the carcasses of animals fed manufactured feed had considerably less body fat than those fed chicken heads. The quality of the meat appeared normal in colour and texture. No quantity data on carcass composition has been recorded yet but the opportunity to grow more meat per animal than fat will have advantages for industry.

The cost of developing diets for research can be some what misleading and at this stage of the development it is difficult to fully cost and compare with current industry feeds. Semi moist pellets (30% moisture) manufactured at the research level (on-site at Townsville DPI&F) cost between \$1.20 and \$1.43/kg based on the cost of the ingredients alone. A shelf stable pellet was recently developed that does not require refrigeration at a cost of \$1.63/kg. The cost of traditional diets currently range between \$0.65c/kg to \$2.00/kg. To get a more accurate comparison the different diets need to be compared on a dry matter basis. This is where the potential for manufactured feed can be realised along with a better supply and use of nutrients to the animal. Savings will also come via reduced transportation and a reduction in storage costs.

Developing research diets often requires the need for "one off" purchases of ingredients or buying ingredients in smaller quantities than is normally commercially available. Such considerations will increase the cost of developing diets.

Implications

A considerable amount of the research has been already been extended to industry via a rigorous extension program. Detailed information on outcomes from the R&D program can also be found in numerous RIRDC and DPI&F publications. These include: *Crocodile Farming Research- hatchling to harvest*. Published in September 2005 by RIRDC and DPI&F *Crocodile Research and Development Bulletin Volume 3 2001*.

Recommendations

One aspect that could be further examined is the skin quality of animals fed manufactured feed. A very small number of skins have been examined for quality and revealed no apparent problems or defects.

The measuring of body condition in crocodiles and the relationship between meat and fat composition should be a consideration for future research. The ability to produce animals, with more meat and less fat will have important economic implications for the industry. To this end the research group have employed technology used in human nutrition research. The development of Bioelectrical Impedance Analysis (BIA) for measuring body condition in crocodiles will be a useful tool in developing manufactured diets. A detailed article on this work can be found in RIRDC publication No 05/152 titled *Crocodile Farming Research: Hatching to Harvest*.

1. Introduction

Crocodile Farming in Australia 2002-2005

The Australian crocodile industry is a relatively new industry, with commercial production commencing in the early 1980's. Currently established farms are under-going a period of expansion in terms of increasing animal numbers and farm infrastructure (including single pen accommodation) to meet an increasing demand for skin and meat products. The advent of single pen accommodation has seen an increase in the quality of skins produced by the Australian industry. The development of the electrical stunning equipment has aided the expansion of single pen accommodation by making it easier you capture crocodiles and inspect them. In recent times there has been interest from potential overseas investors wishing to establish themselves in the Australian industry or as a way of guaranteeing skin supply for their tanning operations in Europe.

One of the biggest obstacles facing the industry in Australia is the availability of animals even in the Northern Territory where ranching is allowed. In Queensland discussions are underway between industry and government agencies on the possibility of carrying out a trial egg-harvesting program. If the trial proceeds and it proves to be economically viable then this will be a boost to the Queensland industry and it will also act as a catalyst for the industry to develop to its full potential.

The concept of sustainable use of wildlife is not new. Sustainable use of crocodiles is successfully carried out in the Northern Territory, Western Australia and in many countries around the world to the benefit of indigenous and non indigenous landholders. The addition of a sustainable egg harvesting program in Queensland would offer indigenous communities in remote areas a source of employment, and economic opportunity

The 2002-2005 On-Farm Crocodile Research Program.

The title of this report is *On Farm Research of Pelleted Feed for Crocodiles*.

This report focuses on trials using manufactured feed on commercial farms in Australia. The aim of the 'on farm' project was to take the best diets developed at the Department's research facility and trial them under commercial conditions. This work is seen as an extension of the existing research program. The degree of information collected from these trials varied depending on the farm and the circumstances under which the trials could be conducted at the time.

A series of trials were carried out on farms designed to

- examine pellet acceptability and growth responses in young crocodiles
- make observations on pellet acceptability by young crocodiles
- make observations on pellet acceptability by adult crocodiles.

The following farms participated in the project:

- Johnstone River Crocodile Farm
- Koorana Crocodile Farm
- Melalueca Crocodile Farm
- Hartley's Creek Crocodile Farm
- Crocodile Farm NT
- Crocodylus Park
- Lagoon Crocodile Farm.

2. Objectives

1. Initiate on-farm feeding trials using the most successful pellet diet from the research program.
2. Implement use of an environmentally friendly and consumer acceptable crocodile feed on farms.
3. Establish the feeding and growth response for farmed crocodiles on trial (pelleted) diets- the trials will cover hatchlings, juveniles and growers >2 years old.
4. Purchase of a Bioelectrical Impedance Analyser (BIA) machine or similar equipment so that growth response measurements will be standardised across farms.
5. Promote growth of lean crocodiles to meet market demand.
6. Compare on-farm pellet feed costs with traditional diets of chicken heads and kangaroo meat.

3. Methodology

General research procedures for on-farm research.

The key objective in this initial on-farm trial is to measure acceptability of manufactured feed by commercially held crocodiles. It is not about measuring the nutritional efficiency of different types of manufactured diets. That will come later when acceptability is achieved.

Another issue that needs to be addressed at the outset is that on-farm trials do not have in general the facilities that are normally associated with research facilities. Notwithstanding research facility limitations on commercial farms, on-farm research provides valuable information to commercial producers and researchers alike. Having identified what the researchers were trying to achieve and one of the limitations they are confronted with under field condition it now remains to be said what exactly the researchers wanted to measure and how they went about making measurements:

- They wanted to measure pellet acceptance by commercial crocodiles. In particular they wanted to measure feed intake, determine feed conversion ratios, measure growth rates determined by weight and length, measure mortality and make some assessment about skin quality
- Further, they wanted to make measurements of the performance of two groups of animals on each farm. The first group would be fed traditional diets such as kangaroo and chicken heads. The second group would be fed manufactured feed.

In order to identify individual animals over the course of the trial it was proposed that they be either tagged or scuted. Ideally the animals should come from the same clutch or clutches if possible. However, if this is not possible then the new group was established using statistical stratification methods.

Pelleted feed for the farm trials will be manufactured by the DPI&F to a standard specification and manufacturing procedure to ensure a uniform product across commercial farms.

4. 2003 on-farm research

In 2003, a series of on farm feeding observations and growth trials were undertaken. Trials were carried out to examine the acceptability of manufactured feed and in some trials the growth response was measured of young crocodiles fed manufactured feed. The “acceptability studies” in most incidences simply involved farm staff feeding pellets to young crocodiles and making observations based on the animal’s reaction to the pellets. It also involved measuring the amount of feed consumed and body condition. In these trials, feeding data may only have been recorded and no data collect on animal’s growth rates.

Nevertheless, these trials still play an important role. The observations made and information provided by experienced farm staff is important and useful contributions to the continued development of manufactured feed for farmed crocodiles. Some farms were able to conduct acceptability and growth response trials. These trials were done in a comprehensive and scientific fashion and are reported accordingly.

The opportunity to develop a pellet for breeder crocodiles also emerged during the course the project. Breeder pellets were manufactured at Townsville and involved observations on “acceptability” for adult crocodiles.

During 2003 ‘on farm’ research has been carried out at the following farms: Melaleuca Crocodile Farm, Mareeba, North Queensland, Koorana Crocodile Farm, Rockhampton, Crocodylus Park, Crocodile Farms NT in the Northern Territory. Koorana Crocodile Farm at Rockhampton Queensland commenced manufacturing its own pellets with diets and ingredients supplied by the crocodile research group. In all trials the feed was manufactured, supplied and distributed by DPI&F Townsville.

2002 Developing Manufactured Feed for Breeders.

The development of a ‘breeder pellet’ was undertaken in late 2002 with the formulation of an initial ‘base’ diet. Comparatively speaking breeder nutrition, within the current project (RIRDC project No DAQ-287A) was not considered as a high a priority hatchling and juvenile diets. This is due to the fact that a farm’s main feed costs are associated with growing animals through to harvest. Accordingly the greatest costs savings and benefits will be made in this area through the development of hatchling and in particular grower manufactured feed. The development of a breeder pellets while opportunistic at the time, offer several advantages over traditional diets including handling and storage. Also traditional diets are unlikely to supply the range of nutritional requirements for a breeding animal.

The objectives of developing manufactured feed for adults are to:

- determine the acceptability of manufactured feed to for breeders
- provide improved nutrition for breeders
- improve the ‘base’ diet should adults responded favourably to the pellets
- determine if imprinting by hatchlings is possible thus leading to a better acceptability of manufactured feed to young hatchlings.

Manufactured feed allows for improved nutrition supply for breeders through diet manipulation. Vitamins and minerals can be added particularly calcium for bone maintenance and egg production. Given that adult crocodiles are not actively growing, crude protein percentage and energy supply is less than those of young crocodiles. These initial levels can be reduced, if deemed appropriate, thus further reducing the cost of the diet. Additives such as flavouring can be added to examine if there are any preferred odour or taste.

Another aspect to the development of a breeder pellet was a consideration of imprinting of hatchlings. If adult crocodiles, would readily accepted manufactured feed then perhaps imprinting maybe possible.

Sneddon *et al* (1998) reported that hatchlings could be induced to take flavoured feed if they had been conditioned to a chemosensory stimulus in the embryonic stage.

It was hypothesised that if imprinting did take place from mother (fed pellets) through to hatchlings then gaining acceptability of manufactured feed to young hatchlings would be greatly enhanced. (Further studies into acceptability of manufacture feed for young crocodiles can be found in RIRDC publication No 05/152 titled *Crocodile Farming Research: Hatchling to Harvest*).

Through the addition of a “home made” extruder attachment to the existing feed milling equipment the research group were able to manufacture a 500gram semi moist pellet. Pellets are cut manually (at this stage), so the size and weight of pellets can vary. Pellets weigh approximately 500 gram pellets each and measure 150 cm in length and 60mm in diameter.

2003 On Farm Observations- Breeder Pellets

Melaleuca Crocodile Farm, Queensland

In October 2002 manufactured feed was supplied the Melaleuca Crocodile Farm to determine if adult crocodiles would accept manufactured feed. Pellets were offered to two females only. One female accepted the pellets readily while the other rejected them after initially accepting them. Eggs were collected from the one female who consumed the pellets in seasons 2003 and 2004 and incubated on the farm. Upon hatching, hatchlings were transported to the Department’s research facility at Townsville as part of the research group for 2003 and 2004. These hatchlings were used in trials to test the hypothesis of imprinting on hatchlings.

Observations on Breeder pellet acceptability

The two females were introduced to pellets at the beginning of October 2002. The timing coincided with the return of the animal’s appetite after the cooler winter period. The following observations were made:

- the initial response to the pellets was favourable with both females readily accepting pellets.
- animals had no difficulty in picking up the pellets which are considerably smaller in size than whole or half spent hens
- animals initially consumed between two and three pellets each per week for six weeks
- the smaller of the two females then went off the pellets after this period
- the remaining female remained on pellets for a period of sixteen months and showed not adverse effects
- the animal remained in good condition during this period.

Observations on imprinting in hatchlings

Hatchlings were individually tagged, weighed and measured and housed in the environmentally controlled hatchling facility under standard operating conditions of 32° Celsius for both air and water temperatures. Hatchlings were fed standard hatchling diet for two weeks. Animals were fed five days per week. Hatchlings were observed at feeding time using closed circuit monitors. At no stage during the feeding period did any of the hatchling show any real interest in the pellets. After a two week period the trial was stopped and hatchlings placed back onto standard meat diet.

Breeder Diet Composition

The breeder diet composition is detailed in Table 1. The diet is formulated to contain 30% crude protein (as opposed to 42% for growing crocodile) and 5% fat.

Table 1 Breeder Diet Composition (%)

Ingredient	Percentage
Water	31.5
Kaolin	4.0
Wheat	16.5
Wheat Gluten	15.0
Hydrolysed Feather Meal (85%CP)	6.6
Meat Meal (50%CP)	16.5
Poultry By-Product Meal (65% CP)	5.0
Poultry Fat	1.56
Lecithin	0.015
Limestone Fine	2.56
Choline Chloride 60%	0.2
Vitamins and Minerals	0.5
Banox	0.015
Phosphoric Acid and/or	1.0
Potassium Sorbate	0.3

2003 Juvenile Crocodile Feeding Trials- Observations and Results

On farm trial-Melaleuca Crocodile Farm

A trial commenced on the 1st November 2002 to examine the acceptability and growth response to young crocodiles. The trial involved 20 two year old animals. The animals were housed in the farms environmentally controlled grower shed and were part of a larger group, consisting of 180 animals. The twenty animals were randomly selected from the group. Animals were identified by placing a red numbered plastic tag through a tail scute on the animal. Body weights ranged from 2.3-7.9 kilograms and total lengths ranged between 935-1305 millimetres. Animals were not identified by clutch. The trial lasted 121 days. There was no introduction period where animals could have been weaned onto the pellets. Animals were simply commenced on pellets.

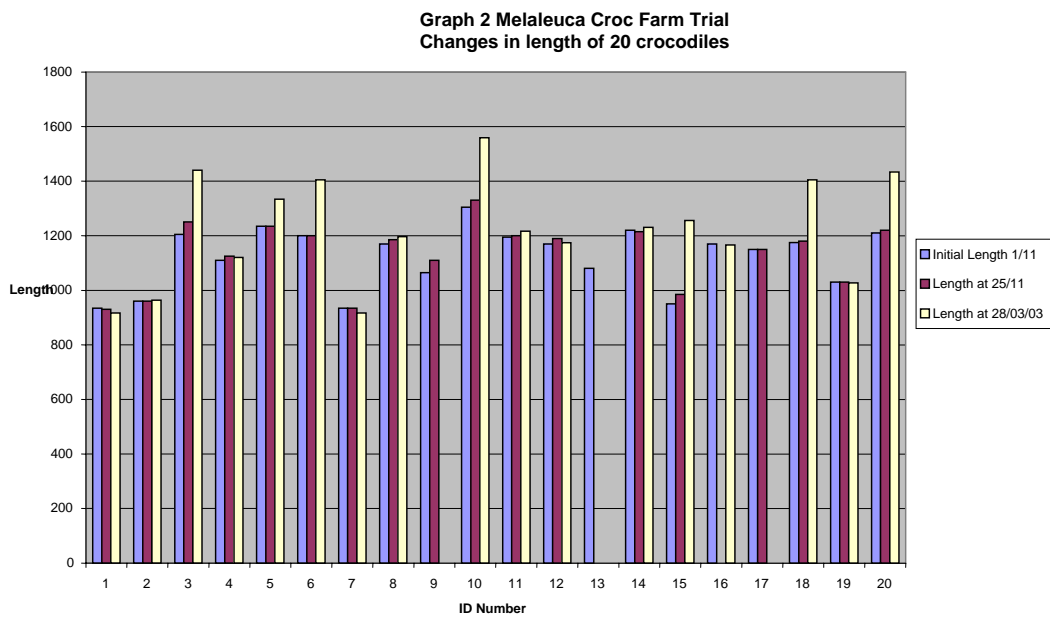
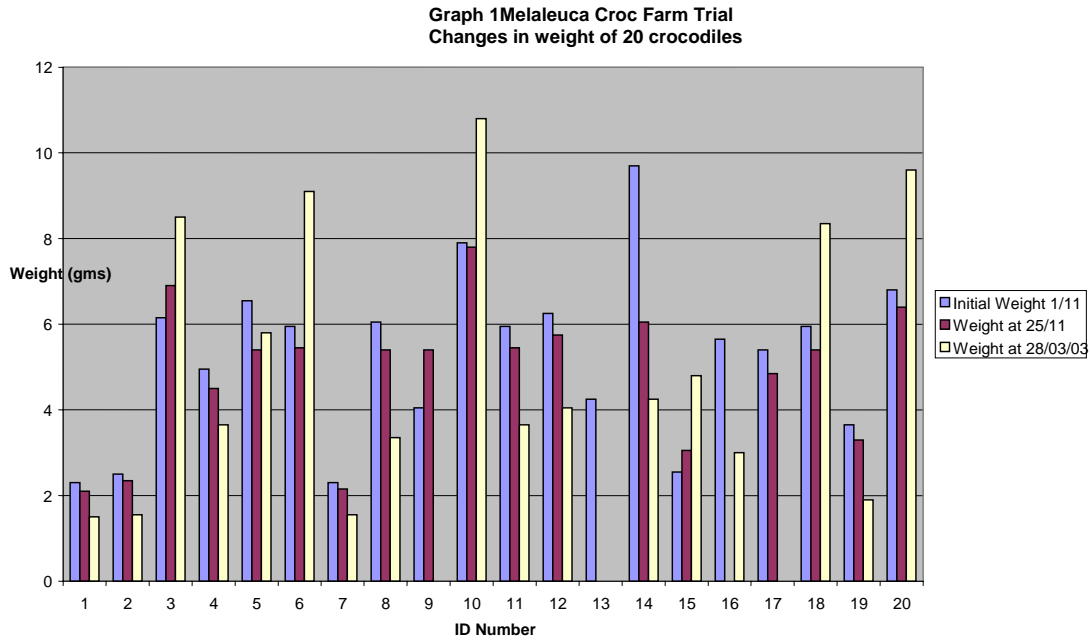
Animals were weighed on the 25th November 2002 and again on the 28th March 2003 (see graphs 1 and 2). Fifteen animals had lost weight albeit a small amount during this period. Weight loss was in the range of 10-65 grams or 6-9.7 percent. One animal (tag no 13) died on the 23rd November. One animal, tag No 16 could not be caught to be weighed leaving three animals which gained weight. At this stage only three animals had gained weight, animal numbers 3, 9, and 15. Weight gains were 75, 35, 50 grams respectively or as a percentage of weight gain 12.1, 8.6 and 19.6%.

At the weighing and measuring carried out on the 28th March 2003. Animal numbers 9 and 17 could not be caught so their measurements were not recorded. Only six animals had increased in bodyweight, numbers 3, 6, 10, 15, 18 and 20 during the period. Weight gains ranged from 160-365 grams or 23.1- 66.9 % weight gain.

By April 2003 the owner reported he was reasonably happy with about half of the group's progress. Those animals that were eating the pellets were growing quite well and readily accepted the pellets. But about half of the group (about 90 out of 180 which included tagged and non tagged animals) were showing signs of not performing very well and were either not consuming the pellets or eating very little. Their condition had started to decline from not eating the pellets.

The trial continued for another month but no further measurements were taken of the animals. The trial ceased and the animals returned to chicken based feed.

The owner reported that the pellets were less obstructive on the farms filtering system than the discarded feathers from chickens that are normally fed out. No research has as yet been done to examine the environmental impact of using manufactured feed. Should manufactured feed have less an environmental impact than traditional diets then obviously this will be another important advantage over current practice. Also manufactured feed contents considerable less fat than chickens and this has increased the efficiency of the filtering system and reduced the number of times the filtration system had to be cleaned during the trial period. The water in the pens still required the same amount of filtering but the system was able to cope better when manufactured feed was used. This has important implication in managing waste water on farms



Crocodylus Park

Crocodylus Park Crocodile Farm, conducted two trials in 2003. The first trial was based on observations to assess the acceptability of manufactured feed by juvenile crocodiles. The second trial compared the growth response between crocodiles fed pellets and chicken head. Standard hatchling diet was supplied to the farm.

Acceptability Trial April 2003

Two pens containing sixty animals in total were used in this trial. Pen No 4 contained animals ranging in length from 1-1.3 metres. The second pen, contain animals of the same size but was also made up some smaller animals, measuring 0.8-0.9 m in length. Pellets were fed out by simply throwing them onto the land area of the pen to test the reaction of the crocodiles. The following observations were made by staff.

Pen No 4

- when pellets were thrown into the pen there was an immediate response by crocodiles to pellets that were in close proximity to the crocodiles
- approximately 45% of the pellets that were fed out were picked up by crocodiles within about five minutes of feeding
- while it was difficult to track individual crocodiles, most appeared to eat some pellets and actively looked for more
- one animal was observed to eat 5 pellets, this took 4-5 minutes pellets that fell into the water were retrieved from the bottom and eaten
- most pellets took about 15-20 seconds to consume, although this varied up to 60 seconds and in some cases up to two minutes
- animals generally “chewed” the pellets, causing them to become compressed into a flat paste and making them more difficult to swallow

Pen No 1

- of the pellets fed out about half appeared to be taken by crocodiles
- of the pellets taken about 40% were eaten
- 30% of pellets were taken into the water after being chased by other crocodiles, these pellets were observed to be eaten
- further 20% of the pellets were dropped after aggressive behaviour between crocodiles
- 10% of the pellets were rejected after the crocodiles tried unsuccessfully for about two minutes to eat them
- smaller crocodiles (under a metre) appeared to have the greatest difficulty in handling and swallowing pellets
- handling time was longer, pellets became flatter, tacky in consistency and difficult to swallow
- pellets would stick to the roof of the mouth of some animals
- despite some handling difficulties being observed by some animals pellets staff, believed that these preliminary results were encouraging and look forward to continuing the work

**Crocodylus Park Darwin
Growth response Trial May/June 2003**

A trial examining growth response involving twenty-four crocodiles followed the initial acceptability trial during May and June. Animals ranged in size from 1.24-1.44cm and were divided into two groups of twelve (see table 2). The trial commenced 9th May and finished on 5th June 2003 a total of 28 days. One group was feed a standard diet of minced chicken heads on three days per week (Monday, Wednesdays and Fridays). The other group were fed pellets on most days of the trial period.

Table 2. Mean size of animals in growth response trial

Group	Feed type	No of animals	Total length (TL) (mm)	Body Weight BWt (kg)	Head Length HL (mm)
1	Chicken heads	12	1316	7.57	184.9
2	Pellets	12	1316	7.61	184.1

Pellet Fed Group

Ten animals did increase linearly; 0.1 to 1.9% for total length and 0.1-1.1% for head length. The two animals that did gain weight, did so by 4.5 and 12.2% respectively. The remainder of the group lost weight ranging from 2.1 to 7.9% of their initial weight. (tables 3 & 4)

Chicken Head Group

All animals in this group increased linearly by 0.2 to 2.2 % for total length and 0.4 to 2.4% in head length. Two animals lost weight by 2.2 and 2.3% respectively. The other ten animals in the group increased in weight by 2.6 to 17.1% (see table 3 &4)

Table 3. Numbers of crocodiles that increased in total length (TL), head length (HL) and bodyweight (Bwt) during the trial. Numbers in brackets indicate percentage of all animals in the treatment.

Group	Fed	No of feeds	Increase in TL	Increase in HL	Increase in BWt
Group 1	Chicken Heads	11	12 (100%)	12 (100%)	10 (83.3%)
Group2	Pellets	24	12 (100%)	12 (100%)	2 (16.7%)

Table 4 Mean percentage increases in the total length (TL), head length (HL) and bodyweight (BWt) for crocodiles in each treatment, which “increased” or “decreased”

Group		TL	HL	BWt
Group 1	Increase	1.4%	1.2%	6.4%
	Decrease	1.2%	0.6%	-2.3%
	All	1.3%	1.2%	5.4%
Group 2	Increase	1.0%	0.8%	8.3%
	Decrease	0.4%	0.4%	-5.6%
	All	0.5%	0.5%	-3.3%

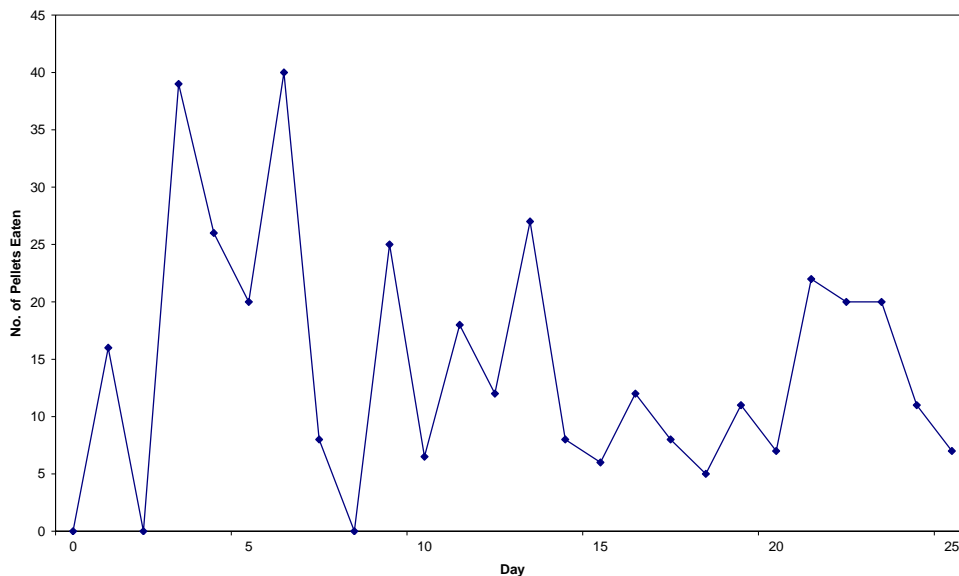
Feed consumed

The overall gain in bodyweight for the chicken-fed group was 4.81kg. To maximise their food consumption, more food was offered to the animals than would normally have been fed out. In all, some 21.5 kg of chicken heads was consumed out of a possible 40.5 kgs offered. This equates to 1.73kg per feed which is equivalent to 6.5% of initial bodyweight per week. This equates to a conversion rate of (wet weight) of about 25% for the minced chicken heads. Errors would be in the direction of less chicken heads eaten as some were dragged into the water, so the conversion rate would be higher. Assuming water makes up 70% of the wet weight, the conversion rate based on dry weight would be 83%.

In all, 1110 pellets were offered to the twelve crocodiles in that treatment. Uneaten pellets were collected, but some may have gone through the grates in the pen and may not have been detected. The figure of 381 pellets eaten is thus considered an overestimate. More pellets appeared to be eaten in the first few days of the trial than in the middle period and consumption may have been increasing towards the end of the trial period (Graph 3). The total weight of the pellets eaten is estimated at 4.79 kg with the mean weight of individual pellets was 12.6g.

It is impossible to know whether crocodiles that lost weight actually ate any pellets at all. However, if we assume that they didn't and that total weight gain for the group was based on the two individuals that did gain weight (1.25kg), then the conversion rate (wet weight) would be 26%. Assuming water content of 10%, the conversion rate on dry weight basis would be 29%. Again errors would be in the directions of less pellets being eaten and conversion rates being underestimated slightly.

Graph 3 Crocodylus Park Trial: Numbers of pellets eaten at each feed



Conclusion

The results from the chicken-fed group reflects, the normal husbandry for these animals. That two animals did not gain weight is unexpected, as this is not an observation seen in healthy animals. However, animals were disturbed and re organised for the trial and this may have affected some animals more than others. The trend may have been different if the trial had been continued for a longer period of time.

Most animals fed pellets lost weight and it is suspected that they simply did not eat the pellets. That most animals grew in terms of length (TL& HL) is not surprising, as they had ample fat reserves on which to continue growing linearly.

Animals were never observed to come straight up and eat the pellets, although some crocodiles fed chicken heads would immediately go to the food after it was placed in the enclosure.

Crocodile Farms NT (CFNT) Darwin

CFNT reports that they had no success with trialling pellets in 2003. CFNT conducted a short acceptability trial over an eight day period. Pellets were fed out to a small group of animals aged 12 months. Animals were fed every second day over this period. Animals were observed to pick up the pellets, mouth them but then discard them.

In a second trial the same animals were fed a combination of minced chicken heads and pellets. Animals consumed the feed but only marginally more successfully than in the first trial.

Lagoon Crocodile Farm Darwin

Lagoon Crocodile Farm reported that they ran an acceptability trial involving animals 12 month of age and older. Pellets fed out over a period of two weeks. Pellets were generally discarded by the animals. The farm then tried a combination of mince meat and pellets with some success but nothing that was considered satisfactory by staff.

Koorana Crocodile Farm Rockhampton

The farm conducted observational studies during 2003 and 2004. The farm reported that they started feeding a 100 meat hatchlings with a 50-50% combination of pellets and fresh meat. Animals are readily accepting this combination with the farm reporting that they will continue to feed at this ratio for the next few months with the aim of reducing the meat content over time. No measurements were taken of the animals. Pellets were not minced in with the meat and this would have had an effect on acceptability as once the ratio gets past 50-50 crocodiles will tend to pick out and eat the meat component. An interesting development that emerged from 2003 trial was that animals feed pellets had smaller head size than animals of the same age that were fed on meat diet. This observation lead to a change in Ca:P levels of the diets.

Koorana Crocodile Farm purchased some second hand equipment with the aim of manufacturing their own pellets. Test runs of the equipment were carried out by the research group. Recommendations were made to change gear ratios to reduce to speed of the auger. A single extruder attachment was recommended as the quality of the pellet produced from the existing multiple extruder were poor. Provided with this information the farm set out to rebuild the feed mill.

5. 2004 on-farm research

During 2004, seven farms were trialling manufactured feed. Trials involved animals at different life stages. Some farms were in their second year of trials while two farms are trialling breeder pellets for the first time.

Research conducted in 2004 at the Department's research facilities determined that a staged weaning process offers the best method of gaining acceptability of manufactured feed to young hatchlings. This process allows for the percentage fresh meat and pellets in the ration to be gradually decreased and increased respectively over time. Farms commence trials in 2004 based on the staged weaning process. Farms reported that they achieved combination of meat and pellets of 50-50 and 60-40 percent with animals performing reasonably well.

Results from trials using manufactured feed only varied, with one farm reported reasonable acceptability rates of 72 and 70 percent. Whilst another farm reported that hatchlings initially accepted a diet of pellets only, then "went off them" after a few feedings.

Crocodile Farm NT Darwin

Farm reports that approximately 200 hatchlings were put aside for trialling. Pellet and meat combination proved more successful than pellets alone. Trials involving a weaning process reached the stage of 60-40 percent mix of meat and pellets before an outbreak of *Streptococcus spp* caused the trial to end. Animals were approximately five months old and 75 cm long and an estimated average live weight of 700grams when the trial ceased. The pellets were only mixed in with the fresh meat as opposed to mincing in with meat. Animals of this size in another trial group were rejecting small pellets at this stage.

Trial results showed consumption between control meat diets and pellet group were similar. At this stage the farm observed a noticeable difference in the appearance of each group in relation to weight. The control group were getting larger and fatter in size while the treatment group were of similar length but thinner in appearance. Meat and pellet group while thinner were considered not to be unhealthy

Lagoon Crocodile Farm Darwin

A trial commenced on 11th October and finished on 19th January 2005 lasting 87 days involving 60, six month old hatchlings. Five animals were randomly selected, identified and weighed at the beginning of the trial. The weight of these animals ranged from 1.005 to 1.140 kgs. No measurements of the initial lengths were supplied. Animals were fed six days per week in a staged weaning process as described in table No 5. The weight of the feed and residues were estimated using a measuring cylinder as per normal on farm practice. Consumption at all stages of the feeding regime was good. The first week of the trial the animals left 15-40 percent of the feed. On most occasions after the initial week there was virtually no feed residues left in the pen. It was not until the 50-50 pellet/meat ratio that residues started to be noticeable. Consumption in this period varied with 10-50 percent of the feed being left. Changes in weight are given in Table No 6. Feed conversion was 'estimated' at 7:1. The trial ceased on the 20th January when the larger animals within the group had to be graded and sent to the grower facility

Table No 5 Detailing the feeding regime used in the trial.

Day	% Pellet/Mince mix
1-16	10%
17-24	20%
25-40	30%
40-55	40%
56-87	50%

Table No6 Initial and final weight of the five randomly selected animals.

Croc number	Wt at 11/10/2004 (kgs)	Wt at 19/1/2005 (kgs)	Wt gain (grams)	% increase
1	1.109	1.518	0.409	36.8
2	1.056	1.516	0.460	43.5
3	1.088	1.806	0.718	65.9
4	1.140	1.686	0.546	47.8
5	1.005	1.630	0.625	62.1

Comment

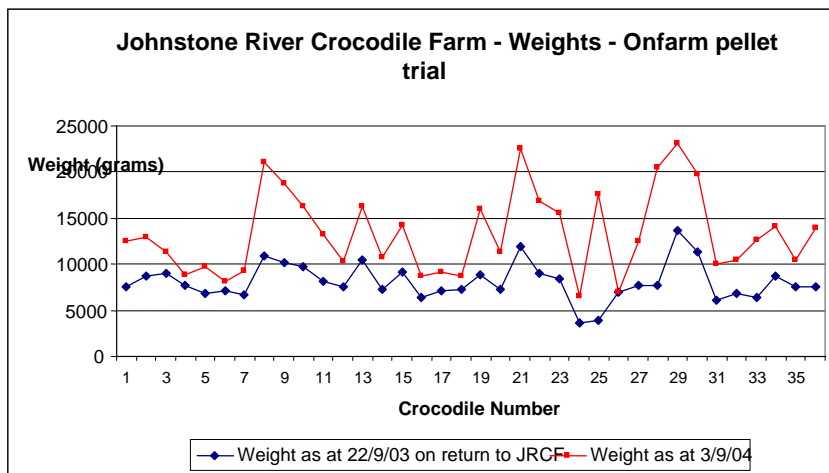
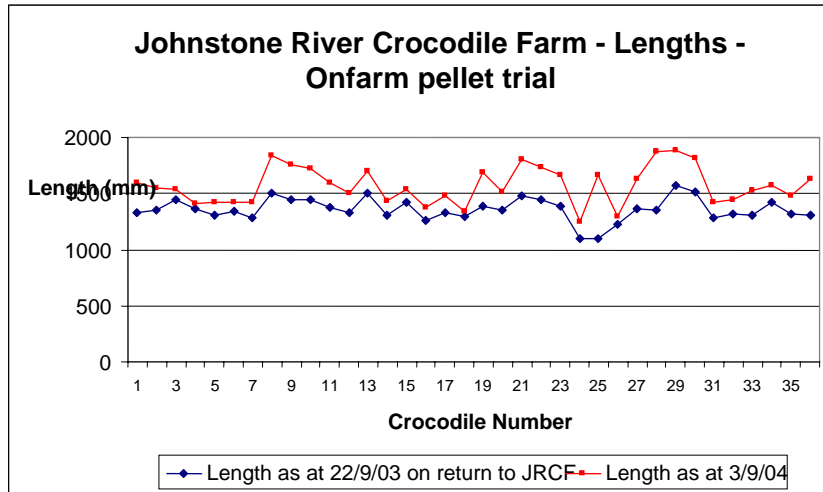
The animals appeared to have no problem in accepting up to 50% pellet in a pellet/meat mix. After this stage, consumption started to vary. This may have been caused by a number of factors apart from the increased amount of pellets in the diet affecting acceptability. Behaviour of the animals may have “kicked in” and influencing the social hierarchy of the group. On a dry matter basis the animals would have been consuming more at the 50-50 than the other feeding ratios, hence the possible cause for the increase in residue. But given that other farms had similar results, then it is unlikely to be the case.

Previous observations and research has shown that reaching 50-50 is relatively easy and any increase in the percentage of pellets from 50% difficult. Animals will pick out the meat and leave the pellets.

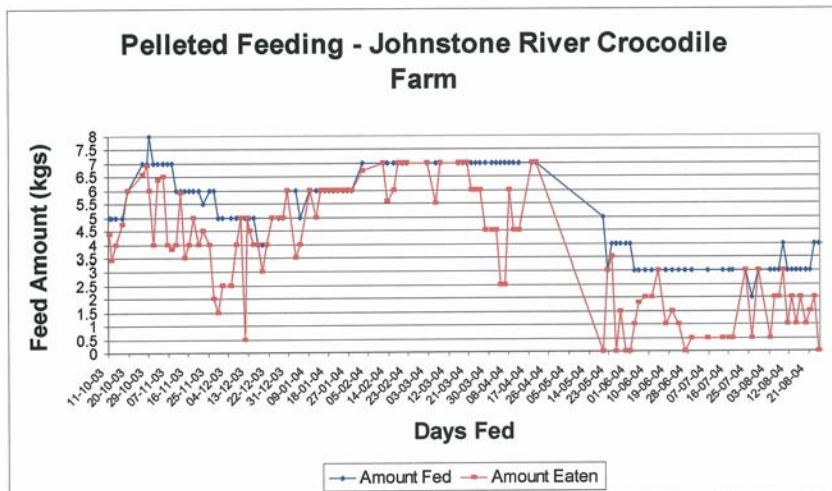
Johnstone River Crocodile Farm, Innisfail

Forty-two animals aged 30 months old were returned from the Department’s research facilities to the Johnstone River Crocodile Farm in October 2003. The animals were housed in a single pen and continued to be fed pellets supplied by the Department. This group of animals represents the first opportunity for animals to be feed pellets through to harvesting. The trial can be summarised as follows:

- animals returned to farm in early October 2003 and finished on 3rd September 2004
- animals settled into new environment quickly and commenced eating on 11th October
- six animals were harvested during the trial period, five animals on the 22nd April and one animal on the 16th July 2004
- average increase in length was 210mm and average body weight gain of 5.31kg over the twelve month period
- average daily gain in length of 0.6mm/day/croc
- average daily gain in body weight and 15.3g/croc/day
- these results are similar to those achieved at the Departments research facility
- observations made by processors at harvesting indicated that they felt that the pellet fed animals had considerable less body fat than chicken head fed animals that were being processed at the same time.



Graph No 4 & 5 showing initial (22/9) and final (3/9) weights and lengths of trial animals.



Graph No 6 detailing feed consumption for trail for trial period.

Notes on Graph No 6

- animals ate a total of 432kilograms during the trial period
- animals were given new diet (same protein levels)
- new diet introduced on 23/12/04 had no bloodmeal, included shellgrit, acidifier, mycosorb and additional vitamins and minerals
- appears to be less peaks and troughs (until May when cooler weather started) with new diet and this may also be due to the fact animals became accustomed to the pen and tourists
- Consumption may have been affected by heavy rain on 27/11,29/11,1/12, 5/12 and 11/12 (large dip)
- Consumption affect by cold weather in late may, June, July and August
- No feed intake record for the period 20/4-20/5/04 as feed recording sheets were lost so no FCE could be calculated

6. 2005 on-farm research

Crocodylus Park, Darwin

A trial of pelletised feed was started in August 2005 at Crocodylus Park Darwin. The aim of the trial was to assess the degree to which artificial rations could be added to standard diets, through feeding, growth rate and overall health of Saltwater Crocodiles.

Fifty Saltwater Crocodiles were assigned to one of two groups (control, experimental). Each group comprised hatchlings from the 2004/05 nesting season, from a number of wild nests, but of similar size, condition and feeding performance to date. Each hatchling was measured [total length (TL), body weight (BWt)] and any observations on body condition recorded. Mean TL and BWt for Group A were 506.1 mm (range 447 - 556 mm) and 372.2 g (range 295 to 499 g) respectively. Mean TL and BWt for Group B were 495.6 mm (range 460 to 527 mm) and 356.6 g (range 237 to 454 g) respectively.

Both groups were housed in adjacent pens, within a hatchling raising facility, and were thus exposed to the same environmental conditions. Food was offered 6 days per week (Mon-Fri, Sun). The feeding regime was:

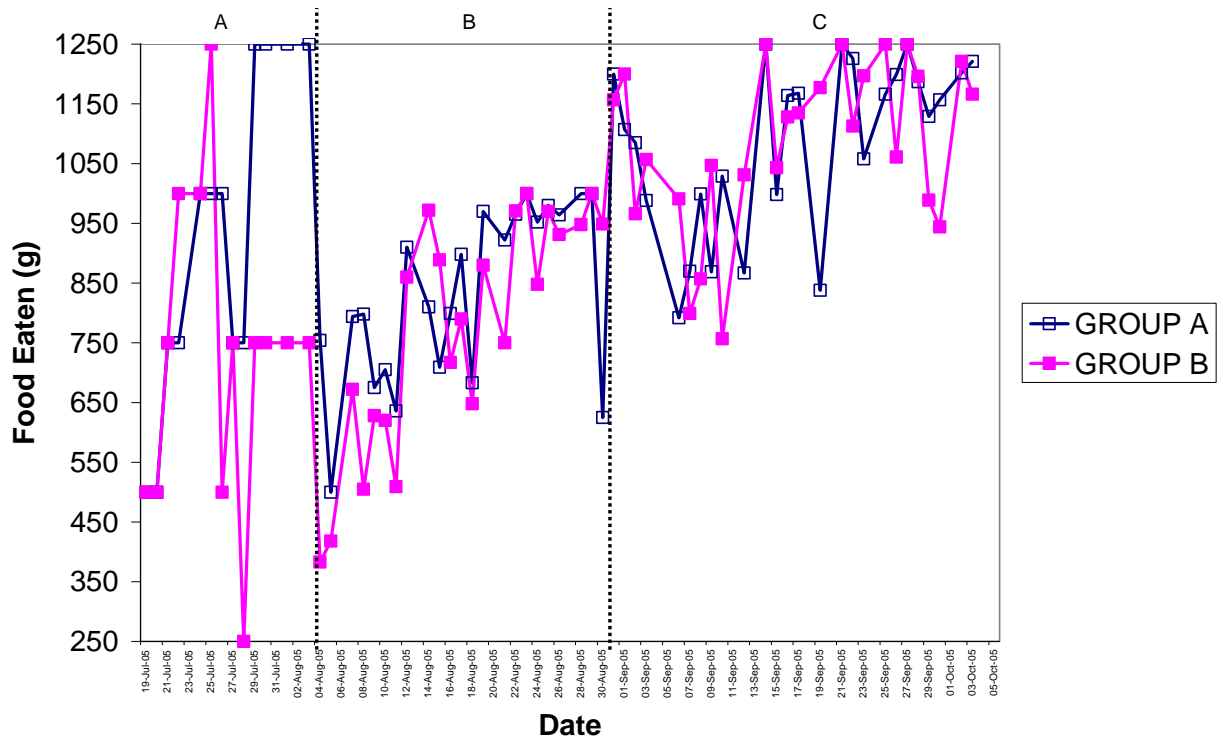
- Prior to the start of the experiment (13 feeds over 16 days), both groups were fed the standard mince (25% chicken heads, 75% red meat, 2% dicalcium phosphate, 2% multivitamin). The amount of food offered to each group varied between each group and depended on the amount of food eaten on the previous feed. The weight of food offered per group ranged from 500 to 1250 g. Food remaining was estimated visually and was therefore approximate.
- From the start of the actual trial and for the next 23 feeds (26 days), Group A (control) continued to be fed the standard mince, but Group B was fed 90% standard mince mixed with 10% pellets (provided by QDPI). Both groups were consistently offered 1 kg of food. Uneaten food remaining on the land area was weighed.
- For the next 26 feeds (34 days), Group A (control) continued to be fed standard mince, but the proportion of pellets in the diet for Group B was increased to 30%. Both groups were consistently offered 1.25 kg of food. Uneaten food remaining on the land area was weighed.

For the first 13 feeds food offered ranged from 500 g to 1250 g depending on feeding performance on the previous feed. When the pellets were first introduced, the amount of food offered to each group was standardised at 1 kg per group. After 26 days when it was clear that all food offered was being consistently eaten by both groups, the amount of food offered was increased to 1250 g. Food was placed into the pens at around 1500 h, on land next to the waters' edge. The next morning (around 1000 h), any uneaten food was collected from the pen and weighed. As crocodiles tended to drag food into the water during feeding, a visual estimate of the amount of food present in the water was made each morning before cleaning. Water was drained, the pen hosed down, and then refilled.

The experiment ended on 5 October 2005, when the crocodiles were mistakenly combined with other hatchlings. As the experimental hatchlings were not uniquely marked relative to other hatchlings, it was not possible to identify them, and so no final measurements were recorded. Feeding performance (Fig. 1) can be summarised as:

- Standard mince: Group A performed better than Group B. Group A crocodiles ate on average 36.9 g per feed, compared with 29.2 g in Group B. However, Group A crocodiles were offered a greater amount of food in the same time period because of their better feeding performance, and this may have influenced the results.

- 10% pellet: Group A performed slightly better than Group B. Group A crocodiles ate on average 33.1 g per feed, compared with 31.1 g in Group B. Group B was catching Group A in terms of feeding performance.
- 30% pellet: Group A and Group B performed the same. Group A crocodiles ate on average 43.5 g per feed, compared with 43.4 g in Group B.



Graph No 7. Feeding performance over time between Group A (Control) and Group B (experiment). Period A represents the 16 days before the start of the trial, where both groups were fed standard mince. Period B represents 26 days where Group A was offered standard mince and Group B was offered standard mince with 10% pellets. Period C represents 34 days where Group A was offered standard mince and Group B was offered standard mince with 30% pellets.

In conclusion, there was no clear difference with regard to feeding between the two groups of crocodiles. It was not possible to continue to a higher proportion of pellets in the feed for Group B, but certainly pellets added at a rate of 30% did not appear to be a problem. The pellets were ground up before being added to the experimental diet, and with 30% pellet content the food was of a drier consistency. However, observations confirmed that the animals continued to eat the food.

Although wet weight consumption was similar in both groups, the dry matter content of the experimental feed was higher. That is, Group B animals were consuming more dry matter than animals on the standard mince, particularly when at 30% pellet content.

Johnstone River Crocodile Farm Innisfail

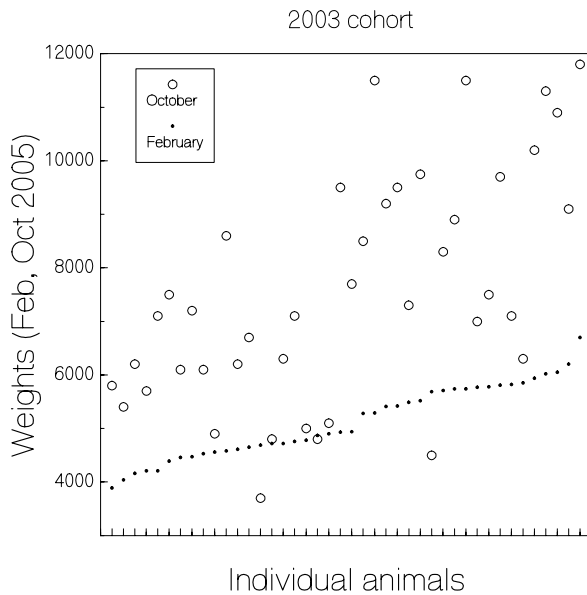
In February 2005, animals were returned from the Department’s research facility to the Johnstone River Crocodile Farm. Of the animals being returned, a group of fifty medium sized crocodiles were selected for an on farm trial. Animals were housed in one pen on the farm. Animals were aged 23 months (2003 cohort) upon return. Animals had been fed pellets for the past twelve months whilst involved in trials.

42 animals out of 50 were weighed and measured on the 25th October with two animals missing both tags (not identified) and 6 other animals missing.

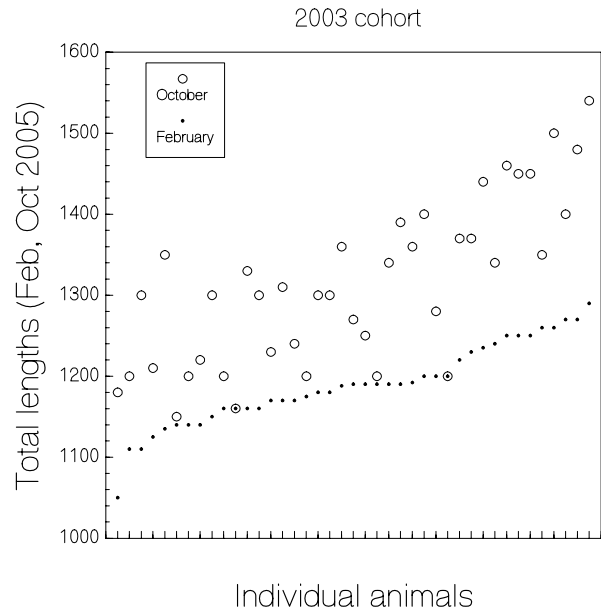
Ten animals from the previous trial were left in the pen so the above figures apply to up to maximum of 60 animals (given some animals were missing as at 25th October). Accurate feeding figures and conversion rate are not possible as it is not possible to determine when animals may have gone missing/or removed from the pen. Information from the trial can be summarised as:

- animals were fed on every second day from the 22/2 to 21/10/05 totalling a period of 241 days.
- initial and final length ranged from 1135-1290 mm to 1150-1700mm and bodyweight range of animals was and (see graph no8)
- initial and final body weight range 3890-6700 grams 3700-11800 grams (see graph no 7)
- 410 kilograms of pellets were fed out during the trial with 266.6 kilograms being consumed, leaving a residue of 143.4 kilograms
- only two animals lost weight during the trial period

Johnstone River On-farm Growth Trial



Johnstone River On-farm Growth Trial



Graphs 7 and 8 showing weight and length of animals on return to the farms (February 2005) and final weight (October 2005).

Adult pellets trials 2004

In late 2004 breeder pellets were supplied to Hartley's Creek and the Johnstone River Crocodile Farms for trialling. Acceptability varied between the two farms. Hartley's Creek fed out pellets to a population of 25 mixed male and female crocodiles in the "tourist" lagoon and to 16 paired breeder pens. Animals were fed once per week and were generally fed one pellet per feed. If a particular female looked down in condition farm staff would offer additional pellets. In general 95% of the animals readily accepted all of the pellets that were fed out. Farm staff reported that the odd animal would chew the pellet and then discard it. There was no noticeable difficulty in with the animals picking up the pellets.

At the Johnstone River crocodile farm the acceptability was poor amongst the adult population. Non flavoured pellets were trialled on both farms.

7. Skin quality of crocodiles fed manufactured feed

The issue of skin quality is very important to an industry where animals are primarily grown for their high quality leather. The issue of skin quality is also of concern to the research group. In late 2004 concerns were raised about quality skins from animals fed manufactured feed by visiting skin buyer and leather manufacturer. The buyer commented that he had purchased skins from animals that had been fed pellets and housed under controlled environmental conditions. The source was not disclosed (and was not from an Australian farm). The problem was that after 2-3 years of using the handbags the gloss finish would start to come off the leather and the leather would then tend to wear badly.

In 2004, animals that were taking part in a feeding trial on a commercial farm were deemed suitable size and skin quality for harvesting. The skins from these animals were sold, and sent overseas for tanning. Arrangements were made prior to the sale with the buyer to return the skins after processing to allow for some analysis to be carried out on the skins. The idea was to compare skin quality between crocodiles fed chicken heads and pellets. Unfortunately the skins were not returned as promised so assessment could not be done at this stage.

In 2005 the opportunity to once again examine skin quality arose. A small number of skins from animals fed pellets and chicken heads were available. The result would serve to provide some preliminary information and their assessment could provide guidelines for any future research proposal. The following points are made in the CSIRO assessment report.

- no gross or subtle differences were seen between the skins
- if there were any they were well and truly hidden by age or tanning process
- the pelleted fed skins were not noticeably weak, spongy or dense
- none of the skins would be unacceptable to an end user
- differences in skin caused by different feeding regimes or other treatments may only amount to 10-15% for factors such as width, symmetry, thickness or strength

To obtain a more accurate assessment of skin quality of pelleted fed animals the CSIRO suggest that a sample size of 50-100 skins be processed at the same time. It will be necessary to run exactly matched parallel samples to detect any differences that might exist between animals fed traditional diets and animals fed manufactured feed. Given the large numbers required this issue would best be examined at a future date, closer to the completion of the research.

8. Bioelectrical impedance analysis

The Bioelectrical Impedance Analysis (BIA) unit to measure meat to fat ratios was purchased in 2002. The calibration of the unit was carried out in May 2003 involving Departmental, Industry and University of Queensland personnel. To date the equipment has not been used in any research work. It has however been used in practice runs and is easy to use and will prove to be a valuable tool in pending research into manufactured feed for farmed crocodiles. Hence in hindsight the purchase of the equipment may have been a little premature given the current stage of the research. However the concept is important in the area of growing animals that meet leather manufacturer's requirements. While significant progress has been made to date, manufactured feed is not yet at a stage where direct and meaningful comparisons on growth rates with traditional diets can be made.

A detail report on this work can be found in the RIRDC publication *05/152 Crocodile Farming Research: Hatching to Harvest*.

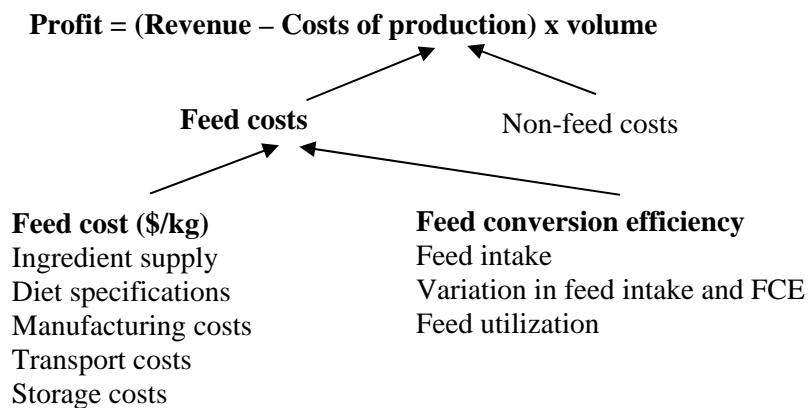
9. Feed Costs

The primary objective of the research project into manufactured feed is to reduce the feed component of farmed crocodile production costs by:

- improving the supply of nutrients
- increasing the efficiency of use of nutrients
- reducing the cost of diets

To date the research program has addressed a number of aspects of crocodile nutrition with a view to reducing the production costs attributable to nutrition. The key components that determine the cost of feed in any intensive animal production system (including crocodiles) are described by van Barneveld (2003).

Figure 2 Key nutritional drivers of profitability as described by van Barneveld are:



Feed ingredients availability and variety that can be used in diets, will have the greatest influence on the cost of manufactured feed. Included in this will be the range of feed ingredients that can be used in the diets, the amount that a particular ingredient can be used in a diet.

Costs of experimental diets

It is difficult at this stage of the development to determine the price for a commercially manufactured pellet for crocodiles. At the research level, diets are changing as the work progresses. Ingredients are added or substituted and alternatives are being examined as possible replacement for animal protein meals. An example of this is the research on including lupins in the diet. In recent time's additives such as acidifiers, mycotoxin binders, shellgrit, enzymes have also been added to the diets. The costs of experimental diets presented in this report are based solely on the cost of the ingredients used, freight and re-handling charges. Costs such as the labour required to manufacture feed and storage costs are not included in the cost. Another factor that increases the costs of experimental diets is, because it is often necessary to buy small quantities of an ingredient. (i.e. 20kg batch of vitamin and mineral premix costs considerable more than if it was purchased in larger batches) these small quantities of ingredients incur a re handling charge. This handling charge has been included in the cost presented below.

An experimental shelf stable pellets (which does not require refrigerated storage) can be manufactured for \$1.43 per kilogram. The cost of hatchling diets are \$1.30 per kg, grower diet \$1.23/kg and breeder diet at \$1.20/kg. One of the outcomes from a nutrition workshop held in 1998 at Townsville was that the price per kilogram should range between \$1-\$1-50/kg. The experimental diets are within that price range.

The other consideration is the dry matter content of the pellets compare to meat diets. On a dry matter (DM) basis, a kilogram of pellets is equivalent to 2.3 kilograms of chicken heads. It is in this area of DM content that the real savings are seen.

The scope for more savings in manufactured feed will come from:

- a commercially semi-moist steam extruded pellet with 10% moisture, current pellets have 25-30% moisture content
- not requiring cold storage
- reduction in labour time required to feed out and cleaning pens
- better growth performance

Cost of traditional diets

Crocodiles are traditionally fed on any red meat, spent hens and poultry by-products such as heads and necks. In most instances feed is required to be transported via freezer road transport over long distances. Examples of the distances involved are North Queensland farms purchase poultry by-products from Brisbane and the Broome Crocodile Farm previously sourced feed from Adelaide and now from Brisbane. Feed costs range from \$0.55- \$2.00 per kg with poultry and poultry by-products at the cheaper range and red meat more expensive. Added to this will be the cost of operating large freezers to store the feed and the labour required to prepare feed.

10. Discussion of results

On farm Trials

Based on the work to date carried out at the Departments research facilities at Townsville a slow weaning process appears to be the best way identified so far to convert animals from fresh meat to manufactured feed. This weaning process may take ten–twelve months for animals to fully accept manufactured feed.

Pellet texture is an important element in gaining acceptability for young crocodiles. In trials conducted at Crocodylus Park some of the animals had difficulty managing the pellets. In these trials the groups were fed the hatchling diet which contains canola oil or poultry fat (for energy). The addition of the oil/fat makes the pellets softer in texture, (than the grower pellets which contain no oil). Pellets may also become “over-soft” after being thawed prior to feeding. This could account for some animals having difficulty in handling the pellets assuming the size of the pellets were suitable for that size crocodile. Also an adjustment to the amount of oil used would assist with pellet texture quality.

The reporting of one farms water filtering system being better able to handle waste water from animals fed manufactured feed is encouraging and should be researched in the future to further quantify any “environmental” advantages that can be found from using manufactured feed

Acceptability of adult animals to manufactured feed at this stage is similar to that experienced with younger crocodiles ie a mixed response. One farm reporting good acceptance with 95% of the animals offered pellets readily accepting them (Hartley’s Creek) while two other farms Mareeba (except for one female) & Johnstone River reported poor acceptance. Flavours have been added to the pellets but these pellets had not been trialled at the time of this report.

None of the participating farms have been able to fully convert animals from meat based diets to manufactured feed. There have been a number of reasons why this has not occurred apart from acceptability of the pellet itself. Disease problems, time and management needs have in part contributed to the non success to date of manufactured feed on farms.

The Bioelectrical Impedence Analysis Unit is calibrated but its use has been limited to date. It is relatively cheap and easy to use. Its use in the research program will become important as diets develop and some attention is given to carcass meat to fat ratio

11. Implications

The objective of the crocodile R&D program is to contribute to the profitability, sustainability and the development of the Australian Crocodile Industry. The nutrition component of the program has been the major focus of the research program. The overall aim of the program is to develop manufactured feeds that are

- acceptable to crocodiles throughout growth
- cost effective
- capable of promoting efficient growth
- optimal in producing quality skins
- easy to manufacture, store feed out and handle

Research to date at the Department's facilities in Townsville has shown that:

1. young crocodiles can achieve growth rates of 16grams/day
2. feed conversion ratios of 3:1 are obtained when animals are fed semi-moist pellets at a rate of 3% of live weight per day. Pellets contain 420g/kg of crude protein; 50g/kg crude fat;630g/kg dry matter
3. staged or slow introduction of pellets provides the best opportunity in gaining acceptability
4. manufactured diets do not require fresh meat as an ingredient to achieve adequate intakes and showed no advantage when they were included in pelleted feed.
5. shelf stable pellets have been developed that do not require refrigeration. This pellet is decidedly harder than the semi moist pellet.
6. cost of experimental diets based on solely ingredient and transport costs range from \$1.23 to \$1.43 per kilogram compared to traditional diets of \$0.65-\$2.00 per kilogram. This cost of manufactured feed, could be reduced further when feed can be produced under commercial conditions.

12. Recommendations

The R&D packages and tools to deliver outcomes for the Australian commercial crocodile industry has been several and varied. The combination of written information, demonstrations and seminars has proven to be effective and should continue.

1. The role of Dr Robert van Barneveld, Barneveld Nutrition Pty Ltd as consulting nutritionist to the project should continue. Dr van Barneveld knowledge, practical skills and experience is critical to the continued success of the nutritional program.
2. The crocodile nutrition program needs to be continued and expanded.
3. A collaborative approach by researchers and industry is still required for the continued development of manufactured feed for farmed crocodiles.
4. Future work is still required to determine formulations which best meet the animals' needs and can be produced on a cost/benefit basis.
5. On-farm experiments need to be continued as they play a key role in the dissemination of research results. Also results can be refined with feedback from client producers to better understand commercial requirements.
6. A weaning process where the proportion of pellets to meat ratio is slowly increased over time appears to be the best way at present of gaining acceptability.
7. Further investigations into a "target weight" where animals will readily accept manufactured feed requires further investigation.
8. Breeder nutritional R&D should be part of any future project proposals. Areas to be examined include dietary requirements, acceptability using attractants and the effects on hatchling production and viability.
9. Follow up work could be conducted to determine if there are "environmental" advantages of using manufactured feed.
10. The quality of skins obtained from animals fed manufactured feed is of a high standard. Further large scale analysis of skins should be conducted simultaneously with diet formulation research.
11. The use of the BIA equipment as a tool in the development of manufactured feed should continue. Trials should determine carcass quality, and in particular to establish desirable meat to fat ratios.

13. References

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