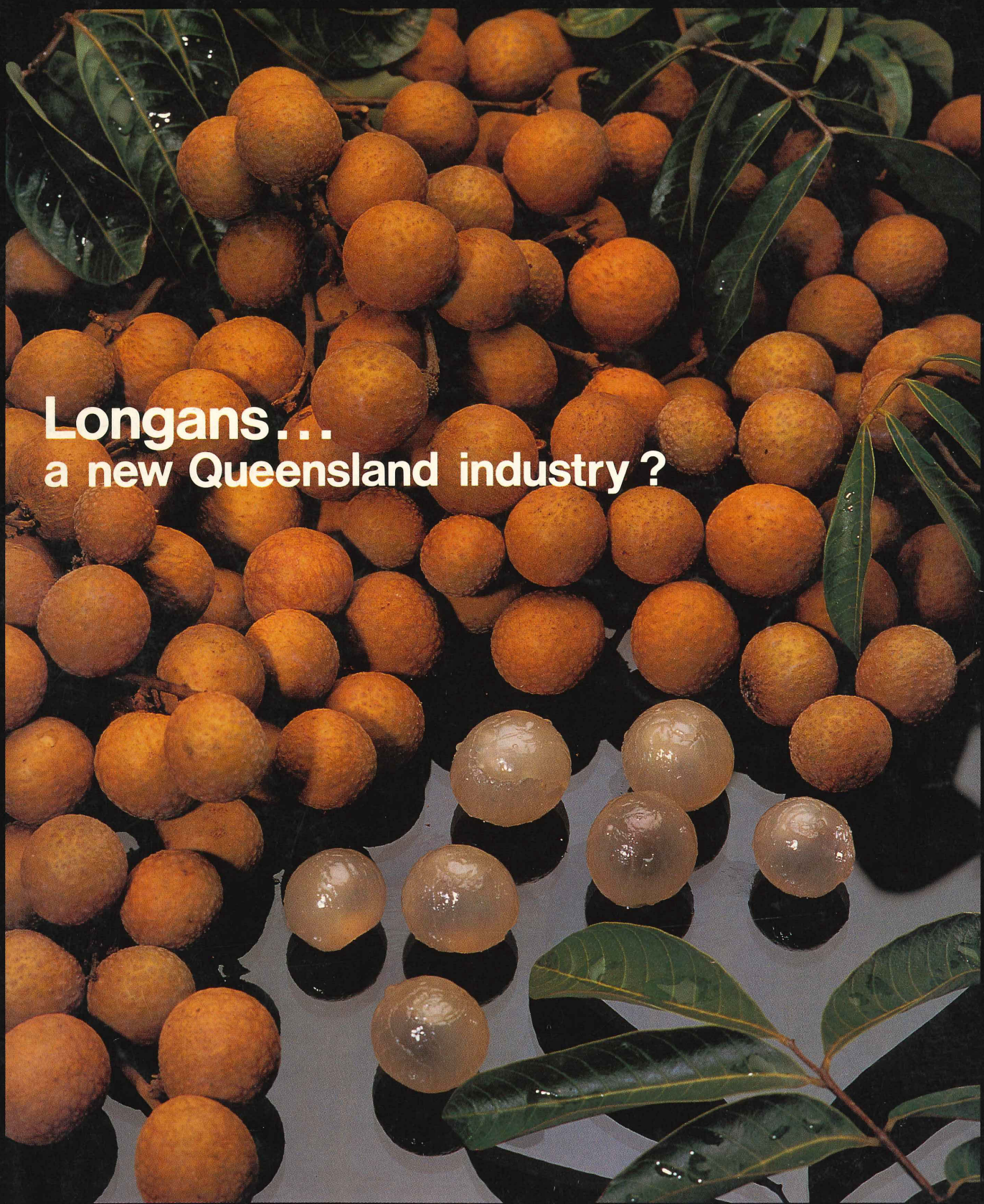
QUEENSLAND AGRICULTURAL JOURNAL

$3.50
September-October 1989
Vol. 113, No. 5



Longans...
a new Queensland industry?

QUEENSLAND AGRICULTURAL JOURNAL

September–October 1989
Vol. 115, No. 5

This issue's cover

Officers from Horticulture Branch are investigating the potential of a range of exotic tropical tree fruits to contribute to the local horticultural scene. One of these shaping up to have a bright future is the longan, closely related to the lychee. The longan is from southern China and has a strong following in many areas of South-East Asia. The crop is an interesting addition to the Australian fruit market with a small industry establishing in the main lychee-growing areas along our eastern coastline.

Publisher
Queensland Department of Primary Industries

Art
Lindy Brennan, Sharon Bettany and André Reginato

Page makeup
Judy Frew, Debbie Harvey, Jenny Vincent

Enquiries
The editor (07) 239 3781 or GPO Box 46, Brisbane 4001. The Queensland Agricultural Journal is published for primary producers, people in agri-business, hobby farmers and students and staff in agricultural education.

ISBN: 0157-7786.

A word from the minister

Hon. David Stoneman, MLA

Rural industry contributes 38% of Queensland's export income, adding $4 billion annually to the state's economy.

During the last five years, Queensland has contributed around 20% of Australia's annual agricultural output.

Queensland is Australia's biggest beef producer and exporter and the world's second largest sugar exporter. We rank third in national grain production and fifth in wool.

The dairy, fishing, pig, poultry and horticulture industries also contribute significantly to the wealth of this state and the economy of the entire nation.

I believe that the key to ensuring the viability of the primary industries sector lies in three main areas – preservation of the family farm, development of land care strategies to protect the future of Queensland's vital agricultural industries and a flexible and supportive government management policy.

The protection of wetlands areas and fisheries is also essential to ensure the future of the fishing industry.

The family farm is a very efficient farming unit. It holds the key to agricultural and pastoral production in this state.

The Department of Primary Industries' Farm Financial Counselling Service has already made an enormous contribution, assisting more than 1500 producers since it was implemented in January 1987.

I am committed to maintaining this service which now has 13 counsellors assisting farmers to assess and improve their viability.

The Primary Industry Productivity Enhancement Scheme (PIPES) also plays a major role, financially assisting producers to upgrade their properties with structural erosion control measures and to prevent overstocking.

The $50 million PIPES scheme allows farmers to increase their viability by expanding and reorganising their operations. It promotes management strategies such as soil conservation, pasture improvement and drought mitigation to enhance long term sustainable production.

Also important in maintaining the family farm are flexible government policies which assist farmers to more ably market and promote their produce, to manage their primary producer organisations and, through research, to remain up to date in their farming and husbandry operations.

The other major issue is land care.

The Queensland Government recently launched a major land care strategy to protect the state's valuable pastoral and agricultural land from the ravages of soil erosion and other forms of degradation.

The strategy is based on the principle that agricultural and pastoral production can be carried out with minimum damage to soil and water resources if appropriate land, plant and animal management practices are used.

This government has a responsibility to every Queenslander and future generations of Queenslanders to protect this state's greatest natural resource – its land.

The Queensland Government is also supporting the land care committees which are forming throughout the state at a rate of more than one a month.

There are now more than 40 such committees in operation. Four regional land care facilitators have been appointed by the department to assist the committees in their soil conservation efforts.

Government assistance in some form is essential to ensure that farming families retain their farms during drought, and to ensure land degradation does not occur through overstocking.

The land care strategy aims to preserve our land resource for future generations by countering the impact of land degradation.

It is policies such as these which will ensure protection of the state's highly productive agricultural and pastoral land.

Please keep it tender

J.M. Beames, Veterinary Public Health Branch

If consumers buy meat which is tough, there is no way they will overlook the fact. While lack of flavour or juiciness may be accepted, toughness will not be.

Few, if any, complaints are received by the Veterinary Public Health Branch about tough lamb, pork or chicken, probably due mostly to the fact that animals and birds are slaughtered at a young age to produce these meats. However, it is a different story with beef. Unless great care is taken at all stages of production up to the finish of carcass chilling, toughness can and does occur.

There are three causes of toughness in beef – age of the animal at slaughter, cold shortening of muscle meat in the chiller and ultimate pH (acidity) of the meat.

Age of the animal

It is a fact that, as a beef animal grows older, more tendinous connective tissue accumulates in its skeletal muscle. This may not be important if the meat is cooked by moist heat (stewing, casseroling and the like) but it is important in the case of grilling cuts – fillet, loin, rib fillet and others. Grilling does not cook the meat long enough to tenderise this connective tissue and thus, if it is tough to start with, it will stay so.

However, scientists have proven that toughness from this cause is not significant until the animal is a full mouth (8 teeth) – from around 4 years onwards. Of course, it is possible to minimise toughness from this cause by slaughtering beef animals at a younger age.

Cold shortening

If a beef carcass is chilled so that its deep muscle temperature reaches as low as 10°C within 10 h of slaughter, any unrestrained skeletal muscle will irreversibly shorten (contract). No amount of subsequent 'ageing' will correct this and the toughness produced can be extreme. This explains why it was felt in the past that a liberal fat cover was important in the production of tender beef – it *was*, it tended to prevent rapid chilling and consequent shortening of the meat.

However, nowadays, fat is looked upon with disfavour by consumers for both health and economic reasons, and cold shortening can be prevented by either tenderstretch hanging the carcass while chilling or electrically stimulating it shortly after slaughter. Tenderstretching physically restrains the expensive hindquarter muscles–rump, loin, round and the like–from shortening. (Most forequarter muscles are naturally restrained whatever method of hanging is used.) Electrical stimulation causes muscles to spasm, exhausting their power to contract, so that they have no 'strength' left to contract even if chilled quickly.

Thus, so far we can see that if a young beef animal is slaughtered, and either tenderstretched or electrically stimulated, two of the causes of toughness have been eliminated. However, it has recently been shown that there is another factor, much more insidious and more difficult to control, which affects the toughness of beef.

Ultimate pH of meat

pH is a measure of the acidity of a substance. If it is neither acid nor alkaline, that is neutral, the pH is 7, as for distilled water. If acid is added, the pH falls, if alkali is added, it rises.

In the living beef animal, the pH of muscles is 7. After slaughter, the muscle sugar (glycogen) is used up by enzymes and lactic acid is produced. This makes the meat more acid and, ideally, enough lactic acid is produced to result in the pH finally reaching 5.4 or thereabouts (the ultimate pH). If this happens, the beef is nice and tender.

This does not always happen, however. In a varying number of cases, the ultimate pH is about 6.0 and, in this case, the beef is tough. The most common cause of this is stress before slaughter, resulting in not enough glycogen being present in the muscles to produce enough lactic acid to bring the pH down below 6. The toughness is caused by the varying time of onset of rigor mortis and the effects of acidity on the muscle fibres.

It is impossible to slaughter any animal without stressing it at all, but the amount of stress varies enormously. Ideally, animals should be rested (if necessary) and moved up to the knocking box as quietly as possible. Excessive noise, rough handling, overuse of dogs, overexposure to cold sprays, inadequate facilities and untrained or unsuitable personnel are some factors which can contribute to high pre-slaughter stress.

If an animal is subjected to extreme stress, that is to the point of exhaustion, there may be practically no pH drop at all, and the ultimate pH may stay up near 7.0. In this case, the meat will be very dark in colour (a dark cutter), but it will be tender.

Therefore, it is vital to avoid stress as completely as possible. Technology can help only to the extent of providing ideal facilities (yards and races) and equipment. However, this is useless unless it is properly used.

So although we can confidently eliminate the other two causes of toughness, this one is far more difficult. Obviously, the provision of well trained and psychologically suitable personnel is of critical importance.

Just how much tough beef is currently being offered for sale is not known, but even small amounts discourage consumers. Everyone in the industry has a part to play in trying to ensure that pre-slaughter handling is as quiet and considerate as possible. This also has, of course, important animal welfare implications.

We can probably never guarantee that all beef in retail outlets is tender, but at least information about how to achieve this goal is well documented.

Lettuce virus diseases

D.M. Persley and **J.E. Thomas**, Plant Pathology Branch

Lettuce crops can be seriously affected by virus diseases. High disease levels in recent years have caused heavy crop losses in south Queensland.

The diseases are favoured by:

- planting crops in succession
- failing to destroy old plantings
- aphid migration.

Management practices which will control disease spread are:

- crop hygiene
- planting seed tested for lettuce mosaic freedom
- destroying common sowthistle, the major host of lettuce necrotic yellows.

The four viruses found on lettuce in Queensland are lettuce mosaic (LMV), lettuce necrotic yellows (LNYV), lettuce big vein (LBVV) and tomato spotted wilt (TSWV). An outline of each follows.

Lettuce mosaic virus

Symptoms

Affected plants are stunted, pale and rarely produce marketable heads. The virus causes light and dark-green mosaic patterns on the leaves. A brown discolouration of the veins may also occur (see plate 1).

Source of infection and spread

LMV is both seed-borne and spread from plant to plant by aphids. Seed-borne infection can be up to 3% in badly contaminated seed lots – levels as low as 0.1% allow serious epidemics to develop. Testing of commercial seed lots over three seasons indicated seed-borne infection was uncommon. However, when it does occur it can provide a substantial source of infection for subsequent spread.

The virus is spread from plant to plant by aphids, with only short feeding periods (less than one minute) necessary for transmission. The virus can be spread by many species of aphids occurring in or around lettuce fields. Common species include the green peach aphid (*Myzus persicae*), the potato aphid (*Macrosiphum euphorbiae*) and the sowthistle aphid (*Hyperomyzus lactucae*). Considerable spread may occur from aphids migrating through a crop, making only brief probes on plants as they move. Planting new crops at short intervals (successional planting) and failing to destroy old plantings with high disease levels are major factors in the spread of the virus. Insecticides are of limited use in mosaic control because of the very short feeding periods required by aphids for spread.

Apart from lettuce, LMV has a wide range of weed hosts but these are generally not a source of infection for lettuce crops.

Lettuce necrotic yellows virus

Symptoms

Initial symptoms are a browning of leaf veins, followed by partial death of the inner leaves. Affected plants are yellow and stunted, often with twisted and lopsided leaves (see plate 2). In advanced stages, the outer leaves can be severely wilted. The symptoms of necrotic yellows and mosaic are often similar, making field diagnosis difficult. Laboratory examination of plants allows the two viruses to be distinguished by the shape of the virus particles.

Source of infection and spread

The weed species common sowthistle (*Sonchus oleraceus*) is the major host of both the virus and the sowthistle aphid, which spreads the virus. This species is the chief carrier (vector) of the virus

Plate 1. Light and dark green mosaic patterns on a lettuce leaf infected by lettuce mosaic virus.

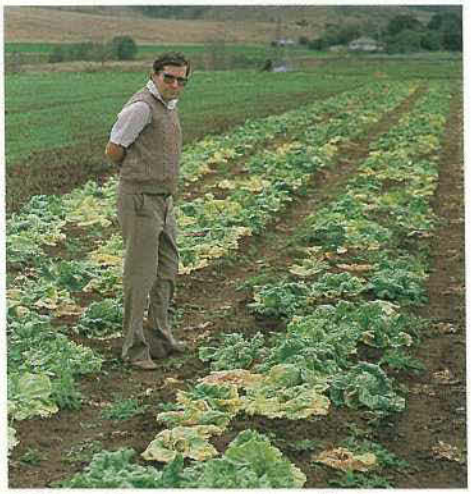


Plate 2. A severe outbreak of lettuce necrotic yellows virus which made the crop worthless.

and can often be found in large numbers on the flower stalks of sowthistle.

Outbreaks of necrotic yellows are almost always associated with infected sowthistles within or near lettuce crops. The sowthistle aphid does not breed on lettuce and there is little plant to plant spread of necrotic yellows.

Lettuce big vein virus

Symptoms

Leaves on affected plants have enlarged, transparent veins (see plate 3). Plants are often stunted with small hearts and upright, ruffled leaves.

Source of infection and spread

The virus is spread by a soil-dwelling fungus (*Olpidium brassicae*). Swimming spores (zoospores) of this fungus infect

Plate 3. Symptoms of big vein disease (right) compared with a healthy leaf (left).

lettuce roots and transmit the virus. Water is essential for zoospore movement. Big vein disease is common in crops grown on soils which retain moisture and in poorly drained areas.

Tomato spotted wilt virus

Symptoms

Affected plants are yellow, stunted and lopsided. Some dark discolouration of leaves may also occur in older plants. The symptoms are difficult to distinguish from those of lettuce necrotic yellows virus and laboratory tests are necessary to distinguish the two viruses.

Source of infection and spread

The virus is spread by thrips and has a very wide range of host plants. The insects usually carry the virus into lettuce crops from infected weeds growing nearby.

Control of virus diseases

Measures which can reduce the level of virus infection in crops are listed below.

- Planting commercially-produced seed tested (indexed) for seed-borne mosaic virus. (Check for a statement to this effect on the container.)
- Destroying old plantings straight after harvesting, as they serve as reservoirs of virus and aphid vectors. There is little point in sowing indexed seed into areas adjacent to old, diseased plants.
- Ensuring that the nursery uses only indexed seed and maintains high standards of insect and weed control.
- Destroying sowthistle weeds, the host of necrotic yellows, in and around lettuce plantings, especially on headlands and unused, weedy land.
- Applying insecticides to restrict aphids breeding within the crop and to provide some control of necrotic yellows virus. The latter is transmitted only after aphids feed for a longer period.
- Avoiding poorly drained areas to control big vein virus. Rotations and soil treatments are ineffective.
- Completely breaking lettuce production district-wide, even for a few weeks. This will reduce the virus available to infect future plantings.

Ludwig Leichhardt and the Sunshine Coast

Dan O'Donnell

One of the really tragic stories of Australian history is the fate of Ludwig Leichhardt, brilliant young German scientist-geographer who literally gave his life to open up 'the unknown continent'. Not quite 30 years of age when he arrived in Australia in 1842, Leichhardt (1813-1848) perished six brief years later on his fateful journey across the continent.

A genius in scientific accomplishment—even today his botanical and geological observations withstand the most rigorous scrutiny—Leichhardt remains a tragic and misunderstood figure in our early history.

While it has never been given the credit it deserves, Leichhardt's first visit to the Moreton Bay District in 1843-44 added considerably to our knowledge of the Sunshine Coast and its hinterland, long before Queensland was born. Indeed, at the time, Wide Bay was the limit of settlement.

In June 1843, having spent 16 months since his arrival in Sydneytown, Leichhardt crossed over the newly-opened road across the Great Dividing Range—Gorman's Road—and continued to Ipswich and Brisbane. In the free town of Brisbane, he voraciously absorbed whatever information was available to him, acquiring a copy of Robert Dixon's recently published map of the Moreton Bay settlement and making new friends. John Kent, the Assistant Commissary-General at Brisbane, was one of these, as was Andrew Petrie, one of the founders of Brisbane. Here he also met Thomas Archer, one of the famous Archer brothers, then located at Durundur (a station in Bunya country in the Sunshine Coast hinterland, near today's Kilcoy). It was this meeting with Thomas Archer which was to bring Leichhardt to the Sunshine Coast.

On 21 July 1843, in company with Archer, Leichhardt set off by horse from Brisbane, reaching Durundur homestead at the foot of a spur of the Bunya Bunya Range (today the Conondale Range) the next day. The spectacular Bunya country impressed the young explorer greatly. 'The Bunya Bunya tree is noble and gigantic, its umbrella-like head overtowering all the trees of the brush,' he wrote to a Sydney friend on 7 August, from near the mouth of the Mary River.

Already the indigenous Aborigines were being observed by his keen eye. 'The Bunya Bunya is by no means a yearly regular crop,' he noted in the same letter. 'It gives rather a feast to the black-fellows than food. Many tribes come at that time to the district, and fight day after day, while the women collect the cones and seeds of the tree, and prepare dinner.'

In letters to his mother back home in Germany, Leichhardt added fascinating details of the triennial feast, held when the bunyas bore their heavy crop. From near and far the Aborigines gathered, Leichhardt informed her, assembling and feasting for about three months.

Three days after arriving at Durundur, Leichhardt set off on 25 July for Wide Bay, travelling first to Mackenzie's station, lying due west of the Archer homestead—roughly where Kilcoy is today—at the time thick with sheep and cattle. From there he crossed the Conondale Range on 27 July and proceeded up the Mary Valley. On 27 July he reached the first outstation of John Eales's Tiaro Station on the Mary River, then known as the Wide Bay River. On 31 July, Leichhardt arrived at Eales's Head Station, spending the next 4 days in the vicinity of the mouth of the Mary River.

It is clear that Leichhardt was not impressed with Eales's prospects of success, especially in running sheep. 'Mr Eels has been humbugged into a new sheep station,' he wrote to a Newcastle friend on 24 July 1843, even before he had seen it, expressing a view apparently confirmed after seeing it. The coastal strip was far too wet, he thought, observing to a Newcastle businessman in May 1844: 'The district is not adapted for sheep farming, though there are some excellent runs at the higher and more mountainous parts of it, but cattle will thrive and fatten not only in Moreton Bay but also at Wide Bay, which Mr Eales was going to leave with his sheep having made a sad experience of a year'.

From 5 August 1843, Leichhardt began to retrace his steps to Durundur, passing through Ubi Ubi country and reaching Durundur on 16 August.

On 31 August, he set off with David Archer and two Aborigines to visit the Glasshouse Mountains, actually ascending Mt Beerwah that very day. These extraordinary geological structures intrigued Leichhardt. 'These mountains are very remarkable' he informed a Sydney friend on 4 September 1843. 'Out of low ranges they rise like meddles, like castles, like those isolated rocks in the ocean to which sailors have given names. The highest of them, Biroa, or Birwah, is about 1000 feet high, and is composed of rock entirely different from the surrounding mountains.'

Leichhardt was certain that 'the sea heaved once round these mountains' citing as evidence the pervasive sandstone ridges and the soil 'composed of pure sand, slightly mixed with vegetable mould'.

By 2 September, they were back at Durundur, where prolonged rain interrupted Leichhardt's program of incessant exploration. According to Archer family diaries, during this period of enforced idleness, Leichhardt's plans for his historic mission across the continent from east to west began to firm. Ludwig 'has a plan for Swan River', one notation reads, a deceptively innocuous entry for Leichhardt's ultimate journey into his tragic destiny.

On 14 September 1843, Leichhardt, David and three Aborigines, set off to explore the Blackall Range. Ten days later he, David and John Archer left Durundur for Durval (now Toorbul), and

Brieves Island (today Bribie Island). The Aborigines of the locality, the Ningi Tribe, impressed him deeply. 'They are a fine race of men', he wrote after returning to Durundur, 'tall and well made, and their bodies, individually, as well as the groups which they formed, would have delighted the eye of an artist.'

On 19 October, he again described his meeting with the Ningi Aborigines. 'I made an excursion to the coast, and had a treat of oysters with my friends, the Nynga-Nynga blacks,' he informed his Sydney friend. 'You could have imagined to enter a primitive village—their bark huts in a circle round a fire and irregularly scattered over a sandy flat, with a swamp, which provided them with fresh water. As I came to them, the one brought me a handful of oysters, the other some crabs, a species of lupaea, the finest crab which Mr Archer or myself had ever tasted.'

By 3 October they were back again at Durundur, Leichhardt's base for extensive exploration in the Blackbutt Range and the Upper Brisbane River region until early March 1844 when he finally left Durundur for Brisbane and his return to Sydneytown. Four years later, mere months before his fateful appointment with destiny, Leichhardt made prophetic reference to the vagaries of weather in the Mary Valley. Good runs were becoming scarce, Leichhardt informed one of his Newcastle friends, the determined squatter having to venture down the Condamine, or north to the Wide Bay or Dawson Rivers. 'I have been at Wide Bay,' he added 'and would not recommend it to anybody, although there may be fair patches of country. In dry seasons it would be tolerably fair, but should wet seasons set in (and when Mr Eales was at Wide Bay they had 9 months continuous rain), all the increase of good years might be lost. I am sure that the Wide Bay country along the Lady Mary River will turn out as the Clarence has done, which was trumpeted out as a magnificent country and is now most wretched.'

The flood rains still come year after year, but neither the Clarence not the Mary River valleys can be described as wretched. But on the question of weather he was not far off the mark as Gympie well knew in 1989.

Sown pastures in strips conserves soil

R.L. Gillespie, Soil Conservation Services Branch

Sown pastures have been successfully established into sloping native pastures in Calliope Shire using cultivated strips across the slope. The sown pasture in the strips is managed to allow pastures to establish in the uncultivated areas.

A common method of pasture establishment in the coastal areas involves cultivating the whole area and can leave the paddock susceptible to erosion. Another recent method involves over-sowing native pastures with a legume, but the legume can be slow to establish and grasses can not be established in this way.

This article describes how Mr Bruce Chapman, owner of 'Rowanlea' near Calliope, has successfully established sown pastures and controlled erosion by sowing strips across the slope. Although the newly sown strips received heavy rain, little erosion occurred. Mr Chapman first used this method to establish Callide rhodes grass in spear grass paddocks and has recently used it to successfully establish a mixture of grasses and legumes.

Benefits

This system of pasture establishment:

- has wide application in coastal native pasture areas
- can be easily implemented with available equipment
- is less expensive than cultivation of the whole area
- provides low cost protection against seed, soil and fertiliser loss.

Method

Mr Chapman cultivates strips approximately 7.5 m wide across the slope and leaves strips of native pasture of equal width between. The cultivated strips are discontinued near gullies to leave the grass cover undisturbed.

Simple methods of siting the direction of the strips across the slope are all that is required. A spirit level or a surveyor's level establishes several key strips across the slope and all other strips are placed parallel to the key strips.

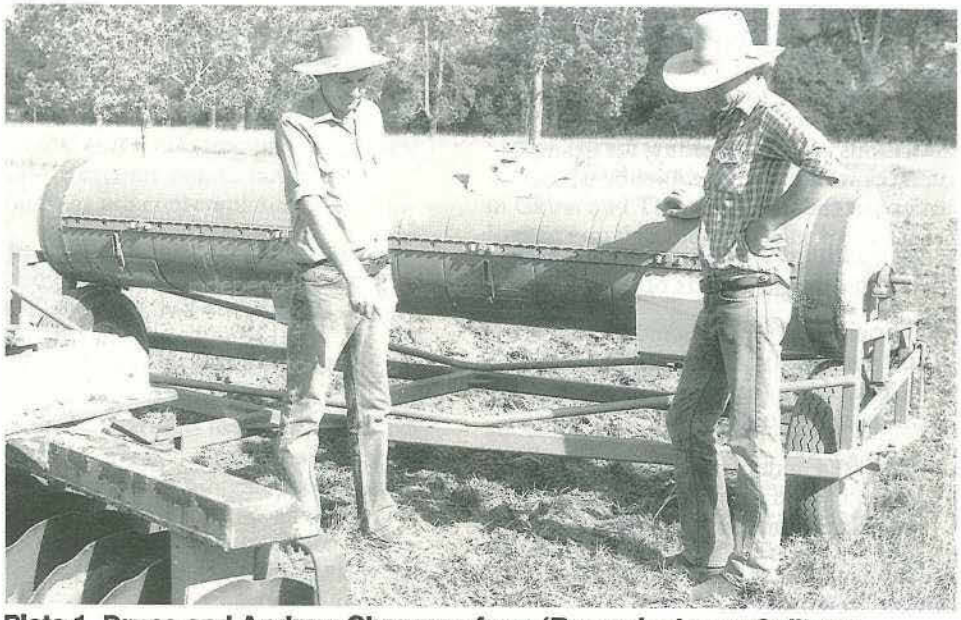


Plate 1. Bruce and Andrew Chapman from 'Rowanlea' near Calliope inspect cultivated strips prepared for sown pastures.

The strips are tilled twice with a heavy disc plough and on the second operation a seeder and harrows are attached. The harrows cover the seed with soil, helping protect them from ants.

Pasture mixture and costs

Recently, a mixture of Callide rhodes, sirato, seca trylo and Wynn cassia was sown on 200 ha. The first tillage operation cost $14/ha and the second operation, involving tillage and seeding cost $53/ha, resulting in a total cost of $67/ha of sown area. Fortunately, Mr Chapman's soil has a reasonable fertility of greater than 10 ppm available phosphorous and can support this pasture mixture. On less fertile forest soils of less than 10 ppm phosphorous, Callide rhodes and siratro would be lost from the pasture mixture unless fertiliser was also applied at sowing.

Management

Mr Chapman has found that by moving stock from the newly sown strips for approximately two months during summer, Callide rhodes grass is spread onto the strips of native pasture. This grazing management is repeated for several years until the whole paddock is established to the sown pastures. He has also noticed that under this management rhodes grass will spread onto bare eroding areas and stabilise them.

Cattle removed from the paddocks with newly sown strips can make full use of other paddocks when native pastures are most palatable.

Contour banks have been used to protect pasture land during the eatablishment period but they have been found to be costly and slow to implement.

Conclusions

Establishing sown pastures in strips across the slope makes good sense on sloping coastal land. It is easy to do, inexpensive and useres readily available equipment. It protects against erosion and is suitable for a wide range of land with native pastures.

Cylindrocladium fruit and leaf spot of custard apple

D.G. Hutton, Plant Pathology Branch, and **G.M. Sanewski**, Horticulture Branch

Developing horticultural enterprises such as the custard apple industry must pay particular attention to the production of blemish-free fruit to encourage increased interest in the commodity on both local and export markets.

Four fungal diseases are known to occur on custard apple fruit: black canker (*Phomopsis anonacearum*), diplodia rot (*Lassiodiplodia theobromae*), purple blotch (*Phytophthora palmivora*) and anthracnose (*Glomerella cingulata* var. *minor*). These diseases occur infrequently and are of minor importance.

Plate 1. Symptoms on fruit of variety African Pride.

Plate 2. Symptoms on fruit of variety Pinks Mammoth.

A new fruit and leaf spotting disease was observed in the Nambour district in 1985. The disease has occurred each year since 1985 and has been found on several other farms between Caboolture and Nambour. It is caused by the soil inhabiting fungus *Cylindrocladium colhounii*. A similar disease caused by *Cylindrocladium scoparum* has recently been found in New South Wales. This organism is commonly associated with disease in native trees and shrubs.

Symptoms are first seen as leaf and fruit spots 1 to 2 mm in diameter on the cultivar African Pride. These spots enlarge and coalesce to form larger irregular patches. The dark superficial spots eventually become dry and cracked. The cultivar Pinks Mammoth appears to be less susceptible but can still suffer severe damage.

The disease usually appears from late March to early April and is most severe during extended rainy periods It is first seen in the lower parts of the tree where leaves and fruit are in contact with the soil or are close enough to be affected by rain and soil splash. Ants carrying soil into trees appear to help spread the disease.

The disease is most serious in situations of high humidity, for example in trees with dense canopies or where trees are crowded.

Two cultural procedures greatly assist in minimising the effects of this disease.

- The skirts of trees should be raised to increase air flow and raise fruit and leaves above the area where they are affected by soil splash.
- The area under tree should be mulched and a continuous grass sward maintained between rows.

These practices reduce soil splash during heavy rain.

Where orchards are being established, ensure the recommended tree spacings are used.

Plate 3. Leaf spots caused by cylindrocladium on variety Pinks Mammoth.

Longans – a place in Queensland's horticulture?

C.M. Menzel, B.J. Watson and **D.R. Simpson,** Horticulture Branch

Plate 1. Fresh longans can be eaten fresh, dried, quick frozen or canned.

The longan from tropical Asia is closely related to the lychee and is similar in growth and fruiting habit. This article outlines the cropping of longan in Australia and indicates it has the potential to contribute to the local horticulture scene. Intending growers should be aware however, that varietal, cultural and marketing problems need to be overcome before large scale plantings are contemplated.

The longan (*Euphoria longan*), which belongs to the *Sapindaceae* or soapberry family from tropical Asia, was officially introduced into Queensland from Sydney in 1854. A longan tree was growing in the Brisbane Botanical Gardens in 1861 but fruited rather poorly compared to a lychee tree growing nearby. Longan plants (seedlings) were listed available from the Department of Agriculture and Stock at Kamerunga State Nursery in 1913.

The longan is closely related to the lychee and is similar in growth and fruiting habit. The tree is tougher and less demanding with respect to climate and soil conditions, and fruits in cooler and drier areas than the lychee. However, the exact environmental requirements for cropping of both species have not been adequately defined. The fruit resemble that of lychee in structure, but are smaller, smoother and yellow-tan to brown in colour. Fruit are also milder in flavour and less acidic. About a third of people in China and Thailand rate the taste of longan equal to that of lychee or better. Fruit can be eaten fresh, frozen, dried or canned. Canned longans are more acceptable than canned lychees.

There are numerous longan trees along the eastern coast of tropical and subtropical Australia, especially in northern areas of Queensland where descendants of Chinese immigrants were responsible for either planting or discarding seed. Some specimens are 50 to 60 years of age. There is one tree in southern Queensland near Nambour which is at least 100 years old. Although heavy yields have been recorded, most trees produce small, thin-fleshed fruit. Consequently, commercial development only began about 10 years ago when better commercial types from Thailand, China, Hong Kong, Taiwan and Florida became available. Some of these cultivars are large fruited types with good flesh recovery and excellent flavour.

Less than 10 000 commercial trees are distributed along the eastern coast around the major centres of lychee cultivation from Cairns and the Atherton Tableland in the north to Coffs Harbour in the south (figure 1). There is one large commercial planting of 1500 trees in northern NSW.

Origin, distribution and world importance

The longan originated either in subtropical China or in the area between Burma and India. Wild longans have been found growing amongst the rainforests on Hainan Island, near northern Vietnam. The tree reached Thailand in the late nineteenth century and Hong Kong, Hawaii and Florida by the early to mid twentieth century. Despite its wide environmental adaptation, the longan is only a commercial crop in China, Thailand and Taiwan (figure 2).

Thailand now produces more longans than China. Longans rate twelfth in order of total production for tropical fruits in Thailand, with an average of 12 to 15 times more longans produced than lychees. This may in part be due to the poor bearing of lychee in Thailand compared to longan. Longan production is centred on the tropical monsoon areas of Chiengmai, Lamphun and Prae (300 m above sea level), the Chiengmai region at 600 m, the Fang region at 550 m and scattered throughout the area between Chiengmai and Fang. It also includes some areas in the central plains north from Bangkok.

In China, Fujian and Guangdong provinces dominate longan production, with the longan more important in the cooler subtropical areas of Fujian. Within Fujian, longans are second in importance only to citrus.

Elsewhere, longan is not a crop of economic significance even in countries where lychee is cultivated commercially,

Plate 2. A large commercial planting or longans in northern NSW. Longan plantings are distributed along the eastern coast around the major centres of lychee cultivation.

such as India and South Africa. Small plantings have been established in Hong Kong, Vietnam, Burma, Indonesia, Malaysia, Hawaii, Florida, California, Brazil and New Zealand. Florida's production is increasing and was about 35 t in 1985.

Botanical relations

The Sapindaceae family contains more than 1000 species from 125 genera, mostly trees and shrubs, but rarely herbs, and with wide distribution in the tropics and warm subtropics. The majority of species are native to Asia, although there are a few in South America, Africa and Australia.

There are seven species in the genus *Euphoria* all from tropical and subtropical Asia, but longan is the only one grown for its edible fruit. *E. didyma* (alpay) has small (2 cm diameter) round green warty fruit with a shell-like rind, big seed and thin, juicy, sweet, edible aril. The tree is native to the Philippines and is widely distributed in both wet and dry areas. *E. malaiense* (mata kuching) produces fruit of similar size to the alpay and longan. Fruit have a tough skin which is pale dull yellow with dark raised specks. The aril, which envelops a big seed, is whitish, translucent and sweet and in good forms nearly 0.5 cm thick, although usually much thinner. Trees grow wild in Malaysia, Borneo, Sumutra and the Celebes.

Other cultivated species from the same family in order of economic importance are lychee *(Litchi chinensis)*, rambutan *(Nephelium lappaceum)*, pulasan *(Nephelium mutabile)*, mamoncillo *(Melicoccus bijugata)* and taun or dawa *(Pometia pinnata)*. Longan is more closely related to lychee than any other species, but differs morphologically in that the flowers have petals and the fruit have flattened or indistinct tubercles on the skin. Fruit are also generally smaller.

The plant and its structure

The longan is a medium to large (10 to 20 m tall) evergreen tree with dense canopy, brittle wood and corky bark which splits and peels. Tree shape mainly depends on the cultivar, varying from erect to spreading. The compound leaves are arranged alternately on the branches and are narrow, large (8 to 14 cm long) and dark glossy green on the upper surface and paler green on the lower surface. The young flushes are red brown, changing to light green with maturity.

The inflorescences are large (30 to 50 cm long), multi-branched and leafless. They are borne on new growth produced during midsummer or autumn, although sometimes they are borne on shoots produced in spring on terminals which have not set panicles. Flowers are small, inconspicuous and yellow-brown.

Plate 3. Vegetative characteristics of longan. Trees resemble lychee in general shape and appearance.

Plate 4. Flowering panicle of longan. The inflorescances are large, multi-branched and leafless and are borne on new growth produced after harvest.

Two types of flowers occur in succession on the same branch of a panicle, usually with overlap on branches and panicles on any tree. They are alternately hermaphrodite with an abortive ovary (functionally male) and hermaphrodite with non-dehiscent anthers (functionally female). All flowers have 5 to 6 sepals and petals and a nectar disc. Male flowers have seven to eight stamens with anthers splitting longitudinally and small ovary with non-functional stigma. Female flowers have a well-developed ovary and stigma and one to two rows of infertile anthers on short filaments. The ovary consists of two carpels each with its stigmatic lobe.

Plate 5. Male hermaphrodite flower.

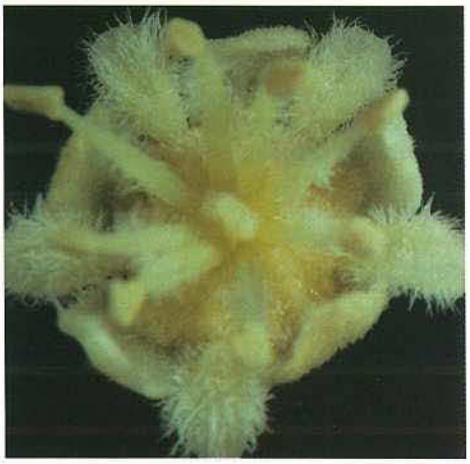


Plate 6. Female hermaphrodite flower.

Longans are less prone to bad weather at flowering than lychee, since flowering usually occurs over six to eight weeks for any one cultivar.

Fruit are small (about 1.5 to 3 cm in diameter), globose to round-shaped, sometimes with distinctive shoulders. Fruit apex is round to obtuse. The fruit skin is thin, leathery and changes from green-yellow to yellow-brown with advancing maturity. Tubercles are typically flattened or indistinct. The aril (flesh) is translucent white to off-white in colour, sometimes with a pinkish tinge (after processing) and ranges in texture from juicy to very crisp and in flavour from bland to sweet and aromatic, seldom acidic.

Seeds are glossy red brown, dark brown to black, small round to ovoid and easily separated from the flesh. The seed apex is variable in shape (flat, round or obtuse). In some cultivars, the apex is wider than the base. Most fruit are full-seeded. A few cultivars set up to 20 to 30% of small seeded fruit. Average weight is 12 to 22 g and flesh recovery 60 to 75%. Fruit size and flesh recovery are related, small fruit normally having a low percentage flesh recovery.

Uses of the fruit

The composition of longan in Thailand is shown in Table 1. Longans can be eaten fresh, dried or quick frozen. Thawed fruit can be used in the same way as freshly picked fruit without any loss of colour or flavour. The fruit can be peeled, pitted and canned. The juice of most cultivars is sufficiently sweet for processing without adding sugar. Fresh or processed fruit can be used alone or with other fruits in tropical fruit salads.

Canned fruit are very acceptable and taste much better than canned lychees. Different cultivars are preferred for canning or drying, others are eaten fresh. Sweet fruit are best used for drying, but those lower in sugar are preferred for canning. Flavour and sweetness are normally correlated. The fresh life of the fruit can be prolonged by storage in polyethylene bags.

Pattern of cropping

Flowering of longans in China and Thailand occurs during December to March (southern hemisphere equivalent: June to September) and fruit mature from July to September (January to March). Flowering is later at Cairns (August to October) and Nambour (October to November), but fruit develop faster and are harvested after four to six months (in mid January to mid March and late February to early April).

Climatic requirements

The cropping patterns outlined above can be explained by differences in climate in the various growing areas (Table 2). Cairns has nearly twice the total rainfall of Chiengmai (2000 vs 1093 mm), while Fuzhou and Nambour are intermediate (1500 to 1700 mm). All areas have a peak rainfall distribution during summer to autumn, more distinct in Chiengmai and Cairns (January to March) and Fuzhou (December to March) and less so at Nambour (November to May). Nambour is the only area to have significant rain in winter.

Winters are warmer in Chiengmai and Cairns than Fuzhou and Nambour. Day temperatures in winter are slightly higher at Chiengmai but slightly lower at night compared to Cairns. During the rest of the year, Chiengmai is warmer during the day than Cairns or Nambour (Cairns is also warmer during the night than Nambour). Temperatures in Fuzhou are similar to those at Chiengmai during summer, but cooler during spring and autumn.

Longans are adapted to tropical and warm subtropical areas with high rainfall. They grow and crop best in areas with short, cool, frost-free winters and long, hot, humid and wet summers.

Longans are sensitive to frost and are killed or severely injured by prolonged temperatures below freezing. They may, however, survive short periods of -1° to -2°C. Flowers and new growth are damaged after a few hours (screen temperatures) at 2°C, mature leaves injured after 4 hours at -3.3°C and trees killed to the soil line after 13 hours or more at -5.6°C. Trees killed to the soil line may not always sucker from the roots. It appears that longans are slightly more sensitive to frost damage than lychees. Freeze damage is the main factor limiting longan production in several areas of southern USA, for example Texas and Florida.

It is recommended that commercial longan sites should not register severe frosts. Even if the tree is not severely damaged, the season's crop will be lost. Cultivar differences in cold tolerance have been noted in China.

Table 1. Longan fruit composition (per 100 g)

Moisture	Protein	Fat	Carbohydrate	Fibre	Ca	P	Fe	Vitamins				
(%)	(g)	(g)	(g)	(g)	(mg)	(mg)	(mg)	A (IU)	B1 (mg)	B2 (mg)	Niacin (mg)	Ascorbic acid (mg)
72.4	1.0	0.5	25.2	0.4	2	6	0.3	28	0.04	0.07	0.6	8

The temperature regime for fruit set and development is similar to that for lychee, but the minimum temperature required to induce panicle and flower initiation appears to be less. In China, the main longan growing area is found in the cooler and elevated environments of Fujian province compared to lychee production, which predominates in the more tropical environment of Guangdong province.

The pattern of longan and lychee growing is reversed in Thailand, longan culture predominating in the tropical lowlands areas of Chiengmai and Lamphun and lychee culture centred in the cooler attitudes and latitudes near Fang.

This difference in the choice of production environment between China and Thailand can be related to difference in cultivars or possible historical factors. The Chinese and Thai cultivars are quite distinct, although Thai material was originally derived from China (not necessarily from Fujian).

Table 2 shows that many areas of eastern tropical Australia have similar climates to the longan growing areas of Thailand and China. Most cultivars have set panicles and flowers at Maroochy Horticultural Research Station, Nambour when the mean daily minimum temperature for the previous 3 months fell below 12°C. In 1986, winter conditions at Walkamin Research Station on the Atherton Tableland were extremely mild and the longan crop failed, except for a small amount of Kohala.

Longans survive droughts but lose production without irrigation in dry environments. The average rainfall in longan growing areas in southern China and Thailand exceeds 1000 to 1500 mm. However, most of this rain is distributed during the period of late fruit growth in summer. The monsoon normally commences after flowering and early fruit growth and finishes before the period of bud burst after harvest. Consequently, the best dryland yields in China and Thailand are obtained on trees growing on alluvial soils with access to the water table.

In Thailand, low temperatures appear to promote flowering, water stress being unimportant.

Excessive rainfall during flowering causes flower drop and prevents pollination and fruit set, while overcast weather before harvest induces fruit shedding, possibly because of reduced carbohydrate production, needed for fruit growth.

Longans are sensitive to wind damage. Strong cyclonic winds cause branch splitting, fruit fall and may destroy the tree. Persistent cold winds retard vegetative growth, while hot dry

Table 2. Climatic data from various longan producing areas in China, Thailand and Australia. Months are southern hemisphere equivalents

Country	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Fuzhou, China (Lat. 26°N)												
Mean monthly max, temperature (°C)	32.1	32.0	29.4	25.7	21.4	17.1	14.0	13.7	16.6	21.4	25.9	29.0
Mean monthly min, temperature (°C)	24.9	25.0	22.8	18.5	14.6	10.3	7.8	7.7	9.8	14.2	19.3	22.6
Total monthly rainfall (mm)	170	189	193	49	41	44	45	89	124	130	161	215
Chiengmai, Thailand (Lat. 18°N)												
Mean monthly max. temperature (°C)	31	31	31	31	30	28	29	32	34	36	34	32
Mean monthly min, temperature (°C)	23	23	23	21	19	15	13	15	17	22	23	23
Total monthly rainfall (mm)	213	193	249	104	30	13	3	10	8	36	122	112
Cairns, Queensland (Lat. 17°S)												
Mean monthly max, temperature (°C)	31.5	31.3	30.3	29.0	27.3	25.8	25.4	26.6	27.9	29.4	30.6	31.3
Mean monthly min, temperature (°C)	23.6	23.7	22.9	21.5	19.8	18.1	16.7	17.6	18.7	20.5	22.4	23.3
Total monthly rainfall (mm)	399	441	464	177	91	51	30	26	36	35	84	187
Walkamin, Queensland (Lat. 17°S)												
Mean monthly max. temperature (°C)	30.8	29.3	27.6	26.0	24.8	23.4	23.0	25.6	26.7	29.2	31.4	30.7
Mean monthly min. temperature (°C)	19.6	20.1	19.6	17.5	15.7	14.3	12.8	13.4	14.6	16.4	18.1	19.1
Total monthly rainfall (mm)	226	327	345	63	13	25	6	19	8	16	78	120
Nambour, Queensland (Lat. 27°S)												
Mean monthly max. temperature (°C)	28.6	28.2	27.2	25.9	23.1	21.4	20.7	22.1	24.2	26.0	27.4	28.7
Mean monthly min. temperature (°C)	19.1	19.5	17.9	15.0	11.6	9.1	6.9	7.5	10.1	13.4	16.1	17.9
Total monthly rainfall (mm)	284	277	247	137	122	82	91	48	45	111	155	180
Alstonville, NSW (lat. 29°S)												
Mean monthly max. temperature (°C)	27.0	26.4	25.6	24.0	20.8	18.9	18.4	19.9	21.8	24.1	26.0	26.4
Mean monthly min. temperature (°C)	18.5	18.3	17.3	15.1	11.9	10.0	8.5	9.6	11.6	13.8	15.8	17.2
Total monthly rainfall (mm)	223	235	226	159	158	143	108	76	69	89	101	142

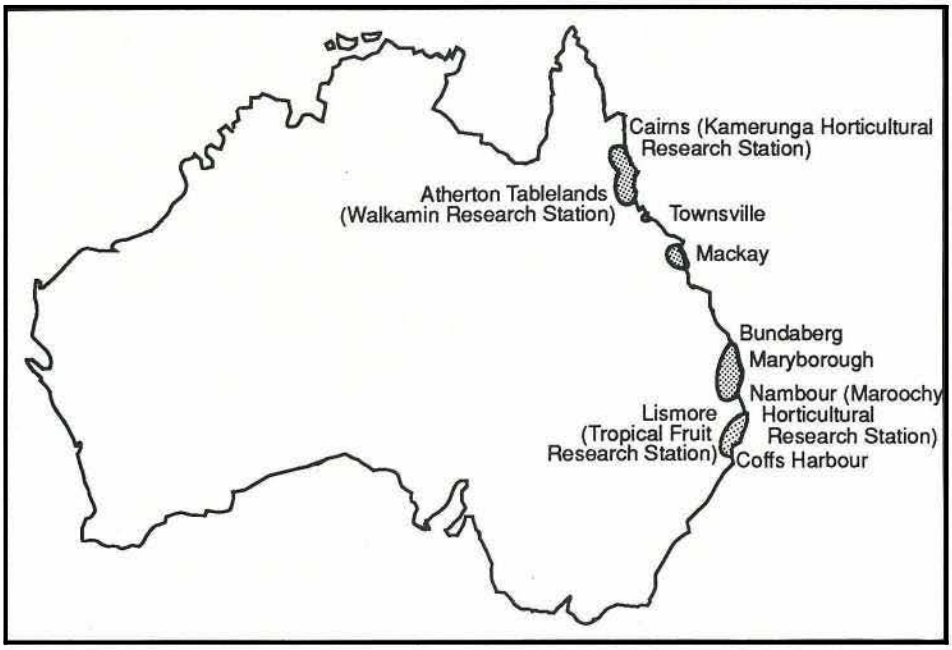


Figure 1. Longan-growing areas in Australia.

winds cause the flowers to dry out and fruit to shed prematurely.

Windbreaks are essential for commercial longan growing. Individual tree guards of polymesh should be erected around young trees for the first 12 to 18 months after planting. Use stakes during this time if trees start to move around in the wind.

Trees in China and Thailand are sometimes mounded after planting, and branches may be supported by posts and bamboo pole fences to reduce wind damage, especially when the trees are carrying a heavy crop. The mounds are built up gradually over time around the trunk of the tree to about 1 m high.

Soil requirements

The best growth and cropping of longan is achieved on deep, well-drained fertile soils with a pH of 5.5 to 6.0 and low salinity.

In China and Taiwan, lychees are normally found growing on better soils than longan. The shortage of arable land has also forced longan production onto hillsides, reducing yields. Trees on heavy soils are usually mounded for at least 0.5 m along the row. Young trees often die in low lying areas. However, the main damage with soils which seasonally waterlog is that trees are more likely to blow over.

In Thailand, the best production is usually on heavy alluvial soils with access to the water table. More recently, irrigation has allowed the exploitation of the better drained soils away from the waterways.

In eastern Australia, the preferred soils for longan growing are heavy, fine, textured soils and red loams with high fertility and high water holding capacity. Low, wet, heavy clay soils are best avoided.

Cultivars

There are more than 300 to 400 longan cultivars in southern China, with about 30 to 40 cultivated commercially. This is possibly because of the long history of longan and the propagation of the crop by seed.

Longan cultivars are relatively uniform and it can take some time to become familiar with the different types. Nevertheless, they vary in tree size, shape and canopy density, leaf size, colour and arrangement, bark characteristics, yielding ability, disease and wind resistance and fruit size, flesh recovery and eating quality. The fruit of some cultivars hang on the tree after reaching satisfactory maturity without loss of quality. Some cultivars are best eaten fresh, others are more suitable for drying or canning. The demand is for large fruited cultivars with high flesh recovery, crisp sweet flesh and good flavour.

Other important characteristics for longan cultivars are regular and heavy yields and a long season (for each cultivar in a region). Good shelf life and processing characteristics are also desirable. Biennial bearing and small seed size have been the major obstacles in breeding and selection. Good fruit size and heavy cropping are not mutually exclusive. However, many of the small fruited types in China, Thailand and Florida are heavy yielding.

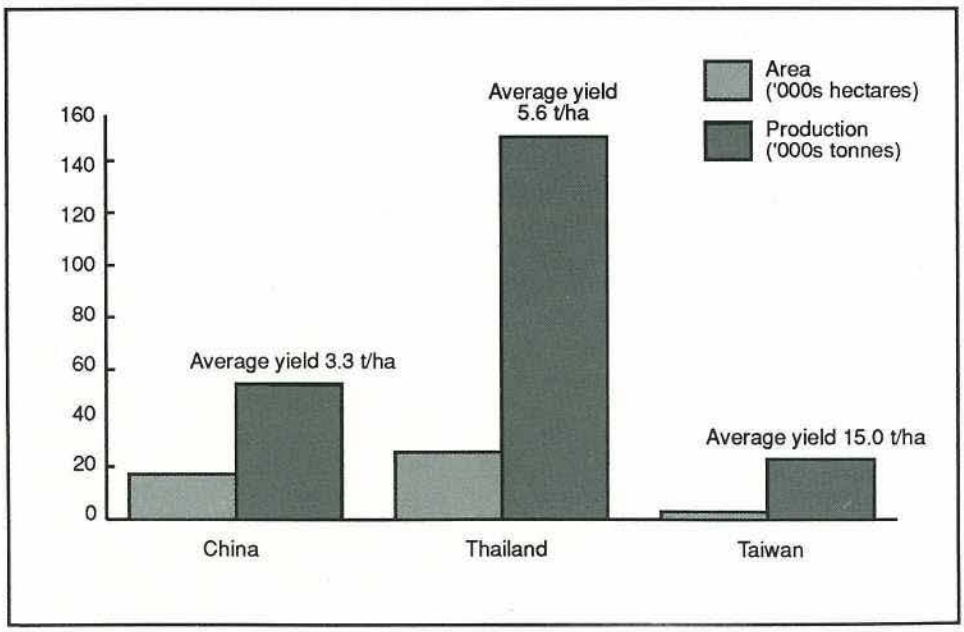


Figure 2. World longan production.

Nearly all longan cultivars originated from southern China or were developed from progeny of Chinese cultivars. The Chinese and Thai cultivars are quite distinct, differing in both environmental adaptation for high yield (see section on Climate) and fruit quality. Thai cultivars are usually more highly regarded, fruit being larger, sweeter in flavour and crisper in texture.

In Fujian province in China, one cultivar accounts for over 90% of plantings. Fu Yan (Lucky Eye) has a long planting history with total tree numbers exceeding 1 million. Fruit are large (18 g) with thin skin, small seed and thick crisp flesh. Yields are high. It is best used for canning, because fruit have a low sugar content (15 to 16%).

The other major cultivar in Fujian province is Wu Long Ling (Black Dragon Peak) with 400 000 trees cultivated. It is a relatively recent selection, being about 140 years old. Fruit of Black Dragon are medium in size (15 g) with thick skin, good flesh recovery and sweet flavour (21 to 23% sugar). Wu Long Ling has a distinct alternate year cropping. Fruit are best dried.

Wu Yuan (Black Round) is the most important longan cultivar in Guangdong province. Fruit are medium in size (15 g), seed large and flesh soft, juicy and of average quality. Sugar content is about 14 to 15%. Yields are high. Fruit are suitable for fresh eating and drying. Seedlings are vigorous and consequently useful as rootstocks.

Shi Xia a (Shek Yip) (Stone Gorge) is the other popular longan cultivar in Guangdong Province, with a history of about 140 years. Fruit are small, but have crisp thick sweet flesh (19 to 20% sugar) and excellent flavour. It is the best fresh eating cultivar and produces heavy crops regularly on unusually large panicles. Shi Xia normally sells for twice the price of other cultivars in the market.

Fu Yan, Wu Yuan and Shi Xia have now been imported into Australia. At the moment, Shi Xia cannot be recommended because of its small fruit size.

The most popular cultivars in Thailand, in order of maturity, are Daw (Early), Dang (Red Seed), Chompoo (Pink), Haew (Water Chestnut), Biew Kiew (Green Skin) and Baidum (Black Leaf). There are also many thin fleshed seedling types (Tammada, meaning common) which are often high yielding, but marketed at lower prices.

Daw is the most popularly grown cultivar in Thailand and is also the most consistent bearer. This is in contrast to its behaviour in Australia where it sets very poorly. Fruit are large with a big seed, thin skin and crisp sweet flesh and good flavour (some fruit may have a sulphur smell). Fruit do not keep well on the tree and the seed may even germinate.

Dang is similar to Daw in productivity and quality (more juicy). Fruit are large with corresponding sized seed. Quality of the fruit deteriorates once they are mature. Trees are susceptible to waterlogging.

Chompoo has large fruit with small seed and is of excellent quality. The flesh is slightly pink after processing and is therefore suitable only for fresh eating. Cropping is not as regular as Daw or Dang, mainly because of poor flowering. This cultivar requires high fertility and good management to yield heavily.

Haew has large fruit with firm flesh and excellent eating quality. Fruit should be tree-ripened for best flavour. The fruit stalk is hard and hence difficult to fold for packing. However, the postharvest life of Haew is good because its thick skin reduces water loss. Fruit are suitable for canning. The main shortcoming of Haew is its alternate bearing habit.

Biew Kiew is highly regarded in Thailand, but is slow to come into production and is irregular yielding.

Table 3. Longan cultivars in Australia

Cultivar	Origin	Introduction number	Location in Australia**
Biew Kiew	Thailand	14909	A-D
Chien Liou	Taiwan	13765	A, B
Chompoo*	Thailand	13204-5, 14911,	A-D
		15455	A-D
Dang*	Thailand	14910, 15452	A, D
Daw	Thailand	13203	A, B, D
Duan Yu	Taiwan	13764	A, B, D
Fa Hok Chai	Hong Kong	13547	B
Fugan	Taiwan	13965	C, D
Fuhko No. 2	ex. Hawaii#	13384	A, B
Haew*	Thailand	16281	A-D
Homestead No. 1	Florida	13201-2	A-D
Ilao	ex. Hawaii#	12809	A, B
Kay Sweeney	Florida	13900	A-C
Kohala*	Florida	11693, 11789	A-D
Ponyai	Florida	12400	A-C
Saig Geeb	China	14674	A, B
Shek Yip*+	Hong Kong,	12594, 17896	A-C
	Taiwan		
Shi Xia	China	17898	A, B, D
Wai	ex. Hawaii#	12810	A, B
Wu Yuan	China	17897	A, B, D

* More than one import.

** A = Kamerunga/South Johnstone, B = Walkamin, C = Maroochy, D = Alstonville.

† Shek Yip (Cantonese spelling) and Shi Xia (Pinyin romanisation) were imported under these names but are assumed to be the same cultivar until otherwise proven.

Source not necessarily place of origin.

Plate 7. Fruit characteristics of Thai cultivar Haew.

Plate 8. Fruit characteristics of Thai cultivars Dang.

Plate 9. Fruit characteristics of Florida cultivar Homestead No. 1.

Fruit are large with good flesh recovery, crisp dry creamy coloured flesh and excellent quality. Dishonest farmers in Thailand sometimes sell Haew as Biew Kiew. Biew Kiew fruit are formed in long clusters and are round compared to asymmetrical in Haew. Biew Kiew fruit are also brown-green versus brown-black in Haew. The leaves of Biew Kiew are thin and shiny compared to the leaves in Haew, which are thick and dull green. Fruit are reported to hang on the tree once they are mature without loss of quality.

Baidum is a regular bearer with acceptable flavour and long harvest period. However, it bears small fruit susceptible to skin cracking and sooty mould.

In summary, the best quality cultivars in Thailand are Biew Kiew, Chompoo and Haew. Cropping regularity is greatest in Daw and Baidum, followed by Dang, Haew, Chompoo and Biew Kiew. All these cultivars are now in Australia.

The main cultivars in Taiwan are Yang Tao Ye (Carambola Leaf) and Chau On Diao (not yet in Australia). We have Chien Liou and Duan Yu from Taiwan, but they are not recommended because of their small size or soft flesh. Cultivars grown in Florida now in Australia include Kohala, Kay Sweeney (large fruit), Ponyai (small fruit) and Homestead Number One (small fruit). Kohala was introduced from Hawaii in 1954 and produces large (12 to 17 g), sweet aromatic fruit with a spicy flavour. Fruit generally have a high percentage of edible pulp. Air-layered trees begin to bear very early and a 3 year old tree may carry 10 kg of fruit. Thinning of flowers and fruit is required during a heavy season to reduce the proportion of small unmarketable fruit.

Cultivars from Hawaii include Fuhko Number Two, Ilao and Wai. Research by Mr Ted Winston at Walkamin Research Station indicates that Fuhko Number Two and Wai should not be considered for planting because they have small fruit or soft flesh. Ilao is a promising new early season cultivar which has a flavour similar to the better Thai cultivars. However, it can possibly be eliminated because of its marginal fruit size (maximum fruit weight about 11 to 12 g).

Most of the important cultivars from the major longan growing areas of the world have been introduced into Australia by Messrs Brian Watson, Keith Chapman, Don Batten and others for evaluation in northern Queensland (Kamerunga and Walkamin), southern Queensland (Nambour) and northern New South Wales (Alstonville). A list of longan cultivars in Australia is shown in table 3.

No longan cultivars can yet be recommended for planting in different areas of Australia because of limited field evaluation. Cultivars which have fruited successfully over three seasons at Maroochy Horticultural Research Station in order of maturity from late February to early April include: Kohala, Dang, Chompoo and Haew. Some trees have produced more than 40 to 50 kg of fruit at year 6. Kohala, Chompoo, Haew and Biew Kiew have proved superior in fruit quality in this environment. Trees normally yield heavily if they flower well. The consistency of flowering of longan cultivars at Nambour is shown in table 4. The cultivars Dang, Chompoo and Haew have fruited at Alstonville but no yields are available.

Excellent yields have been obtained some seasons for Kohala, Chompoo and Biew Kiew longans at Walkamin Research Station with 6 to 7 year old trees producing about 40 to 55 kg of fruit. Other cultivars which have fruited include Duan Yu, Daw, Dang and Haew. Most of these cultivars flower irregularly at Kamerunga Horticultural Research Station. Flying foxes and graft incompatibility also reduce cropping.

No yield data are available for commercial longan orchards in Australia. The only data collected is on the performance of single trees on research stations. Single trees of most cultivars crop fairly consistently at Maroochy Horticultural Research Station (table 4). The yield pattern is one light to medium crop and two heavy crops. Yields seem to be influenced by seasonal weather conditions. It is possible that a biennial bearing habit will be established once the trees are older than 10 years of age and cropping very heavily. A biennial cropping pattern has emerged for mature trees at Walkamin Research Station and more recently at Maroochy Horticultural Research Station, especially for some Thai cultivars such as Haew and Biew Kiew.

At the moment it might be appropriate to plant Kohala together with the better Thai cultivars such as Chompoo, Haew and Biew Kiew. This would give a spread of harvest and less fluctuation in total farm output. There is the possibility that late maturing cultivars such as Haew and Biew Kiew will be strongly biennial bearing in the cooler inland and elevated environments of southern Queensland where fruit are not harvested until April or May.

Table 4. Flowering of longan cultivars at Maroochy Horticultural Research Station, Nambour

Cultivar*	Origin	Flowering pattern†					
		1984	1985	1986	1987	1988	1989
Ponyai	Florida	M	M	L	H	M	H
Homestead No. 1	Florida	L	L	L	H	M	H
Manson	Local	M	H	L	H	H	H
Kohala	Florida	M	L	H	H	L	H
Dang	Thailand	M	M	H	H	L	-
Chompoo	Thailand	H	M	H	H	M	H
Haew	Thailand	H	L	H	L	H	L
Biew Kiew	Thailand	L	L	L	H	H	M

* In order of maturity from late February to early April.
† L = light flowering, M = medium flowering, H = heavy flowering.

Propagation

Longans can be readily propagated by seed. However, most seedlings do not bear for 7 to 8 years and often have biennial cropping, small fruit, poor flesh recovery, poor eating quality and low market returns. The preferred method of vegetative propagation in Thailand is by air-layering (marcottage), although grafting, inarching and cuttings are possible. However, researchers at Chiengmai University consider that trees produced by grafting onto a seedling rootstock do not offer better wind resistance than trees produced by marcottage.

Trees in Fujian province in southern China have been propagated by air-layering for over 800 years. Some nurserymen in China claim a success rate of 80 to 90%, but air-layering has not been used widely in Australia.

Air-layering is usually carried out from October to February in Queensland. Choose a strong healthy branch 2.5 cm in diameter. The most recently flushed growth should be well matured, since flushing branches have depleted reserves and root poorly. Remove a strip of bark and softwood to the cambium layer about 45 to 60 cm from the tip of the branch. Take care with the cincture to remove all tissue back to the central wood. Unless this is done, the cambium layer will regrow and rooting does not occur. Wrap a plastic bag filled with wet peat or sphagnum moss around the cincture to make a root ball 6 cm in diameter and 20 cm in length.

Remove air-layers after about 2 to 4 months, when the roots have turned from white to creamy brown. Trim plants to a good structure and remove half the leaves. Establish plants in nursery bags or pots under warm humid and partial shade conditions. Plant trees out after 6 to 12 months.

Longans have been successfully propagated by grafting in autumn and spring under shadehouse conditions in Australia. Use scions of semi-hard terminals about 0.5 cm in diameter with leaves attached. Cleft-graft into a node subtended by a leaf. Enclose the graft in a polythene bag or frame to prevent desiccation. Seedlings are normally suitable as rootstocks after 12 to 18 months of age. Work from Thailand and Queensland suggests that some scion/rootstocks are incompatible. Researchers recommend grafting a variety onto seedlings of the same cultivar. In Australia, preferably graft onto seedlings of the same cultivar or at least not Thai cultivars on Chinese rootstocks or vice versa.

Several methods of grafting have been used in China, including budding, whip and tongue, crown, side wedge and inarching. The preferred methods are budding and whip and tongue. Success rates are normally greater than 80%. Forkert budding has been found to be successful with longan cultivars introduced into Australia.

Cuttings with mist and bottom heat have been struck successfully at Kamerunga Horticultural Research Station. Hard, thick terminal wood about 25 cm long with full leaf cover taken in winter has provided the most reliable material. Treatment with auxins has not proved beneficial.

Florida researchers have produced young longan plants by growing leaflets of new vegetative flushes in tissue culture. These leaflets produced calluses and eventually embryos, depending on the concentration of growth hormones in the tissue culture media.

Embryo culture of longan has been initiated in China. Young undeveloped embryos about 3.0 mm in length could be grown in tissue culture and small plants produced after 3 to 5 months. Embryos from both 'full seeded' and 'aborted seeded' fruit could be successfully cultured.

Spacings

Tree densities vary from 50 trees/ha in mature orchards in Thailand to about 300/ha in high density plantings in Taiwan. Tree densities in Fujian province range from 195 to 300/ha, with an average around 270 trees/ha.

Higher density plantings (6 × 6 m spacings) are likely to be more profitable, provided young trees bear fruit and the fruit fetches reasonable prices. Well grown trees fill their spacing in 6 or 7 years. Top and root prunings extend the life of high density plantings in Taiwan and Thailand to about 15 years before some trees have to be removed. In Florida, longan trees are sometimes planted at wide spacings and the interrow area interplanted with other crops.

Land preparation

Land preparation should begin 3 to 6 months before planting. Planting usually occurs in late summer to early autumn or in spring in cold, wet or frost prone areas. The objective is to ensure quick and even establishment of young trees.

Establish waterways

Establish permanent grassed waterways to carry runoff water. Waterways are essential if mounds or terraces are planted.

Ripping

Deep rip before planting to ensure uniform growth and minimum plant losses. Ripping is essential in previously cultivated soils where a plough layer has formed. Deep ripping to the depth of 1 m is done down the rows during dry weather to cause soil shattering rather than compaction as will occur in moist soils.

Terracing

Establish terraces on slopes. Use mounds of 0.5 m to aid drainage in heavy, poorly drained soils.

Cultivation

If cover crops are to be planted the whole area should be cultivated for seeding. If no cover crop is to be planted, or on steep slopes, cultivate only the tree rows.

Cover crop

Cover crops are desirable, but not essential, before planting and between trees during the first 3 to 4 years of orchard life. Cover crops suppress weed growth, offer good wind protection for young trees and provide an onsite source of undertree mulch. Suitable species for an early summer sowing in southern Queensland are hybrid sorghum (September) or maize (August). Where a short season summer crop is required, millet can be planted. For early winter sowing, the alternatives are lupins, oats, wheat or barley.

Correction of pH

Correction of soil acidity should be done before cultivation because lime or dolomite should be incorporated as deeply as possible to obtain maximum effect in the root zone. Surface applied lime can be slow to penetrate and may be lost with surface soil erosion. The pH should be 5.5 to 6.0.

Fertilising

A good uniform planting results from proper site preparation. At least 3 to 5 months before planting dig or rotary hoe into the 1 m square planting site 10 L of fowl manure or 35 L of millmud and 500 g superphosphate and dolomite if required. The need for these latter two should be based on soil analysis.

Planting

The best time to plant is from spring and autumn. When planting, care should be taken not to wrench the root system off: the potted plant should not be carried by the stem. During planting, ensure firm contact between the root system and the soil mass. The plant should be firmly staked and tied to avoid wind damage.

Different cultivars should be planted in separate blocks or at least in different rows. This causes less confusion with timing of watering, fertilising and spraying.

Early tree management

Young trees are grown as vigorously as possible for the first 4 years to attain the greatest tree size and bearing surface. Vigorous growth is achieved by regular applications of water and nutrients, strategic pruning and protection from frost, wind, weeds and pests.

The nutrition programme begins when the trees begin to flush after planting. Apply 30 g urea monthly and 30 g Fertica every 3 months increasing to 80 g urea and 80 g Fertica in year 4. Fertiliser should be washed in by irrigation. On poor soils, apply organic fertilisers in spring in the first few years. Suggested rates in the second year are 25 L millmud or 8 L fowl manure increasing to 35 L millmud or 15 L fowl manure in year 4.

Do not place fertilisers within 50 cm of the trunk as young longan trees are sensitive to fertiliser burn. If there is risk of frost, only apply fertiliser during spring and early summer so that plants are not flushing when winter approaches.

If trees are well grown and flushing is vigorous in the fourth year, stop fertilising with nitrogen until the first crop is picked. If nitrogen levels are not controlled, trees may not begin to bear regularly for several years (longans are more fruitful at an early age compared to lychees). A well grown 4 year old tree is about 2.0 m high with a canopy of 1.0 to 1.5 m in diameter.

Pruning for tree structure

Pruning produces well formed tree crowns, strengthens fruit bearing branches, ensures annual cropping and limits insect pests and diseases.

Longan trees produced from seedlings and marcots can grow up to 12 to 18 m, which causes great difficulty in harvesting and tree management. However, grafted trees can be pruned to a workable height of 6 to 8 m. In Thailand, all longan trees are pruned regularly with all water shoots and small branches from the interior of the tree removed. Trees are skirted to a height of 1 to 2 m. In China, one strong branch is retained after every growth flush to form a natural round-shaped crown of 6 to 10 main branches.

Details of pruning young trees have been given for Thai longan growers. Trees are cut to a 1.2 m trunk and 3 to 4 vigorous young shoots selected from the regrowth to form the main framework of the tree. These laterals are forced into wide angles from the trunk with the aid of sticks. Two branches are left on each lateral shoot. Similarly, two sub-branches are left on each branch and so on. Finally, the canopy consists of 24 to 32 sub-branches, which may be

achieved in the third or fourth year. The tree is quite short with good light penetration through the canopy (figure 3).

The flower spikes of young trees less than 5 years of age are normally removed in China and Thailand to encourage growth and crown expansion during summer. On the other hand, early cropping of young trees can have a desirable dwarfing effect in high density plantings.

Growers in China and Thailand apply soil around the trunks of trees each year in summer to provide mounds (to a height of 0.8 to 1.0 m) to strengthen the trees' anchorage against cyclonic winds. Trees are also inarched with seedlings, but this is not a common practice.

Management of bearing trees

The vegetative and flowering cycle of longan is less sensitive to environmental conditions compared to lychee. Excessive vegetative growth during the autumn-winter period does not usually restrict flowering because it occurs later during cooler weather than in most lychee cultivars. However, longans have a distinct biennial pattern of fruiting, which may be related to tree management and environmental stresses.

Longan shoots, flowers and fruit are formed on terminal branches. There are normally three periods of vegetative flushing during the year: spring flush (in non-fruiting terminals), mid summer flush and autumn flush. Flower panicles are borne in late winter, fruit set in late spring and fruit mature in early autumn. The greatest period of flushing occurs after harvest in autumn. Flushes also develop from behind panicles which have not set fruit in summer. Weak flushes may develop at the same time as flowering panicles in spring. Panicles may form on any of the vegetative flushes. However, most are borne on flushes initiated in mid summer. Flushes emerging in spring and autumn are normally weak because of competition with fruiting shoots or because they develop during cool weather.

During a heavy bearing year, there are few mid summer shoots and few or no autumn shoots. Consequently, there are insufficient vegetative shoots to support the next season's flowering. Heavy flowering usually guarantees heavy fruit set in longan. This results in heavy fruit drop, small fruit and depletion of tree reserves. The typical pattern of yield is a heavy crop with many small fruit followed by a light crop with few large fruit.

For the above reasons, tree management is directed at gaining a balance between vegetative growth during the periods of flushing and the level of flowering and fruiting in spring and summer. The desired control can be achieved by strategic applications of water and nutrients, and appropriate timing of shoot, flower and fruit pruning.

Irrigation

Very little information is available on the irrigation requirements of longan. Trees in southern China and Taiwan would probably benefit from irrigation because the wet season commences after flowering and fruit set. In Thailand, it is generally agreed that irrigation overrides other factors in determining yields, which are usually higher on trees growing along the rivers.

Irrigation is used to encourage bud burst after harvest and to promote flowering and fruit growth, and to reduce biennial bearing. Water stress induces flower and fruit shedding. If fruit are stressed late in development, they may persist on the tree but be small and have a poor flesh recovery.

To control cropping, water trees from the time of panicle emergence, during flowering and fruit growth and after harvest until the maturation of the postharvest growth flush. Apply irrigation at maximum rates (600 to 800 L/tree/week for 10 year old trees in summer) during this period. Withdraw irrigation before flowering unless trees show symptoms of stress and then water only lightly.

A high rate of watering during the main growing period is managed by tensiometers and watering when a unit placed in the root zone (300 to 400 mm) rises to 30 centibars on a clay soil to 10 centibars on a sandy loam. Stop irrigation when a deeper unit (600 to 900 mm) reads 10 centibars. This ensures reserves of moisture at depth.

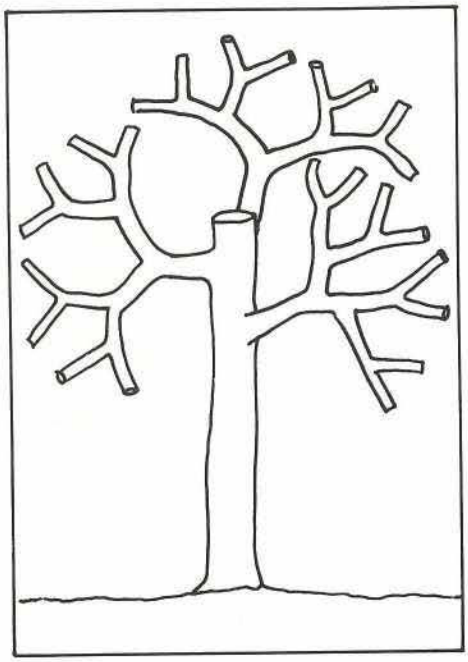


Figure 3. Suggested tree shape at year 4.

Longans appear to be more drought tolerant than lychees in southern Queensland. Flowering and fruit set normally occur during the more humid months of October and November and trees escape the hot dry winds that occur when most lychee cultivars are setting fruit.

Use mulching to reduce water loss from the soil and increase soil organic matter and structure, reduce extremes of soil temperature and encourage growth of feeder roots. If applied correctly, undertree mulching also assists weed control.

Suitable fibrous mulches are wheat or barley straw, sorghum stubble, peanut shells and bagasse. Apply the mulch each year in spring to a depth of 10 to 15 cm. Keep the mulch away from the trunk to prevent collar rots.

Nutrition

Research from China and Thailand indicates that tree nutrition is the main factor affecting fruiting, apart from season temperatures and rainfall. With rational nutrition management, stable yields some two to six times that of neglected trees are possible over several years. Nutrient stress, in particular of nitrogen and potassium, also leads to fruit drop, small fruit and poor flesh recovery.

Fertiliser management like irrigation is directed at manipulating the crop cycle, especially towards promoting panicle growth, fruiting and vegetative flushing after cropping. To meet this desired control, apply fertiliser four times during the crop cycle:

- panicle emergence in July to August (southern Queensland)
- one month before fruit set in September to October
- one month after fruit set in December to January
- two weeks after harvest in March to April (Figure 5).
  These times will be 1 to 2 months earlier in north Queensland.

Suggested rates which have proved reliable for well grown high yielding 5 year old trees under southern Queensland conditions are 625 g nitrogen, 150 g phosphorus and 800 g potassium increasing by 20 to 30% per year to 1250 g nitrogen, 300 g phosphorus and 1600 g potassium at year 10.

Rates of micronutrients applied every 2 to 3 years which have given good results at Maroochy Horticultural Research Station are shown in table 5. Zinc deficiency is common in Thailand. This nutrient along with boron, iron and copper would be expected to be the more common deficiencies in longan growing soils in Queensland.

Table 5. Tentative rate and sources of nutrients for application of micronutrients to longan trees in southern Queensland which should be applied to foliage or soil in June–July (soil application preferred except in red loams where soil fixation of boron and zinc can be a problem).

Nutrient form	Foliar application (g/L)	Soil application (g/m^2 ground cover)
Borax	1	4
Zinc sulphate heptahydrate	2	25
Copper sulphate (bluestone)	2	4
Iron sulphate or chelate	1	10
Manganese sulphate	2	5
Magnesium sulphate (Epsom salts)	2	4

The rates and type of fertiliser applied depend on tree size and vigour, cultivar, crop load, climate and soil type. Fertiliser management should be adjusted according to the response of trees. Keep a record of tree vigour, leaf colour, flowering and yield for each cultivar and block. No leaf or soil nutrient standards are available for longan.

Foliar applications of nitrogen, phosphorus and potassium plus trace (zinc, iron, boron and copper) are sometimes used to boost flower initiation and development by some growers in Thailand but have not been tried locally. Three or four applications are used at 10 day intervals from at least 1 month prior to panicle emergence.

Thinning panicles, flowers and fruit

Pruning of panicles, flowers and fruit is a common practice in longan orchards in China, Taiwan and Thailand. Unfortunately, in Australia we have only limited experience with pruning.

Alternate bearing in longan is very common in most growing areas, especially once trees are older than 10 years of age and begin to crop heavily. Production in an 'off' (light crop) year is usually about 20 to 40% of the 'on' (heavy crop) year.

Orchardists in China and Thailand in an 'on' year consider pruning and thinning of flower buds and fruit as one of the most important techniques to overcome the alternate bearing phenomenon. For instance, in China, growers may remove 40% of the flower spikes and 30% of the young fruit, depending on the crop load and tree vigour, with lower thinning rates for healthy trees with lower setting rates (less than 500 g/branch at harvest). The flowering panicles are pruned when they are about 10 to 12 cm long, when 'weak' and 'strong' branches can be easily distinguished.

Thinning of fruit in China not only reduces biennial bearing but also increases fruit size. Only large fruit (25 cm diameter or 18 g) attract a premium price. Fruit are thinned about 4 to 6 weeks after fruit set when they are the size of a pea. Fruit thinning is essential after flower thinning because of the high rate of fruit set and greater competition for developing fruit.

Orchardists remove all empty spikes to encourage the growth of new shoots during mid summer. Overset panicles are thinned to the greatest degree, depending on the size of the flowering spike, tree vigour and cultivar. Small spikes may carry up to 30 fruit (600 g at harvest) and large spikes up to 180 fruit (3600 g). The fruit should be no closer than 1 cm apart.

In Thailand, longan growers reduce the number of flowers by half (each flower spike is retained) before fruit set in an 'on' year. After fruit set, they remove 10% of the fruit. Under southern Queensland conditions with high labour costs, it might be more appropriate to remove a proportion of the spikes rather than to thin the flowers. The amount of thinning required will vary from season to season and orchard to orchard. Low vigour, high yielding trees require the greatest amount of flower and fruit thinning. Hand thinning is very time-consuming and expensive in Australia. However, it will be some time before chemical thinning is available for longan growers.

Small fruit is a serious problem in southern and northern Queensland. For instance, at Walkamin Research Station, only Kohala, Homestead Number One and Biew Kiew had more than 80% of fruit greater than 25 mm in diameter in unthinned crops. Most of the other cultivars had too low a percentage greater than 25 mm to be commercially viable. Small fruit would be the major agronomic constraint to longan growing in Australia.

Thinning of spring shoots

In an 'off' year, growers in China and Thailand remove a proportion of the shoots produced in spring to reduce competition between the shoots and fruit, and so reduce the amount of fruit drop. It is generally considered that shoots produced in spring are not suitable for carrying next season's crop, generally being weaker than those produced in mid summer.

Pruning of fruit clusters and limbs at harvest

Pruning at harvest encourages a flush of growth, especially in trees low in vigour. This involves removing whole limbs to open up the canopy. Too much pruning or removal of too much leaf and wood with the fruit panicles at harvest reduces flowering the next season and aggravates biennial bearing.

Cincturing

Some growers in Thailand cincture their longan trees, but it is not generally recommended by the Department of Agriculture. Provided tree vigour is maintained, most longan cultivars have flowered adequately most seasons at Maroochy Horticultural Research Station. This suggests that cincturing will probably not be required for cropping in southern Queensland at least.

Pollination

It is generally recognised that because longan flowers contain nectarines, they require insects for pollination. Although no comprehensive study on longan flowering has been carried out, the trees at Maroochy Horticultural Research Station are pollinated by soldier beetles, flies (including blowflies) and native bees. The European or honey bee, which pollinates lychee flowers, does not appear to be a major pollinator of longan. It is suggested that harmful insecticides should not be applied during the period of fruit set.

Harvesting, storage and marketing

The season begins with cultivar Kohala in northern Queensland in early January and finishes with cultivar Biew Kiew in southern Queensland in early April.

Longans do not ripen off the tree. They may sweeten a little, but do not develop full flavour. Maturity is judged by the particular shape, skin colour and flavour of each cultivar. Forwarding immature fruit to market to gain high early prices damages the reputation of the grower and the longan in the market place.

Most fruit can be picked from a tree in one harvest and from a single cultivar in an orchard within 2 weeks. Consequently, to spread the picking workload it is essential to plant a range of cultivars in any one orchard. A 4 to 5 month long season in eastern Australia can only be achieved by planting a range of longan cultivars with different maturity times in a range of production environments.

Fruit are harvested by removing the whole cluster plus one or two leaves. Fruit are clipped from the panicles, sorted for size, insect damage and skin blemishes, and placed in bulk trays. Removal of too much leaf and wood with the fruit panicles at harvest reduces flowering in the next season.

Fruit maintain acceptable eating quality for 5 weeks at 5.0 -7.0°C and 90% relative humidity, although significant browning of the skin occurrs. At lowers temperatures, there is a rapid loss of eating quality, principally associated with the presernce of 'off' flavours above 10°C, fruit succumb to post harvest diseases.

Sulphur treatments have been tried in longan in Australia and Thailand. Meta sulphite pads offer some control of browning and post-harvest diseases for up to 4 weeks for punnet fruit stored at 10°C, but can taint the flavour of the flesh.

Unlike lychees, longan fruit do not separate from the fruit stalk easily without the loss of some skin. This could hasten breakdown of the fruit after harvest. Longan fruit, consequently, do not look as attractive as lychees in punnets. It has been suggested that longan fruit should be marketed attached to the fruit stalk in bunches of about 15 to 20 fruit. A small amount of trial fruit was marketed in northern Queensland in 1988, with superior prices received for fruit retained on panicles as compared to loose fruit. A machine for destalking lychee fruit is available in southern Queensland and has possible use for longan. These marketing problems need to be sorted out before crop production rises over the next decade.

In Thailand, most fruit are marketed in branches on the fruit stalks in 22 to 24 kg bamboo baskets and consumed within 3 days without any postharvest treatment. A proportion of the crop is sometimes stored on ice to give a few extra days of shelf life, but there is generally no precooling or refrigeration. Fruit for sale in Malaysia and Singapore are sometimes packed with ice. Fruit exported to Hong Kong are packed with the fruit stalk intact. However, the largest growers consider that average quality is unimpaired when all the raceme stalks are removed.

The price of fruit in Thailand depends on the season, cultivar and fruit quality. For instance, in 1985 the price for longans at Nong Hoy markets in Chiengmai ranged from A$1.05/kg for wild small fruited large seeded types to A$1.84 to A$2.11/kg for large fruited small seeded cultivars such as Chompoo or Biew Kiew. Returns for seedling fruit can be as low as A$0.10/kg, but these trees may yield 300 to 400 kg of fruit consistently. The greatest demand is for fruit with a weight of more than 18 g.

No selection to date has exhibited a heavy regular cropping pattern at QDPI research stations.

Yields

Air-layered trees normally begin cropping 3 to 4 years after planting. Yields of 40 to 50 kg/tree have been obtained for trees at year 6 to 8 at Maroochy and Walkamin Research Stations. These are about half the average yields reported for trees of all ages in Thailand. No selection to date has exhibited a heavy regular cropping pattern and large fruit size at QDPI research stations. In Florida, no selection has been found which fruits regularly. On a given tree (for example, Kohala), good crops occur only 1 year out of 3 or 4.

In Thailand, the average yield for well grown orchards is 120 kg for mature trees (equivalent to 6 t/ha at a density of 50 trees/ha), but there is considerable variation from year to year and orchard to orchard. Many of the orchards are neglected. The industry average is about 14 to 28 kg/tree. Single trees may carry 300 to 400 kg of fruit in a season at 20 years of age. For mature trees of 12 to 15 years of age in Thailand, the yield averages one poor crop, one fair crop and one excellent crop over 3 years.

Most of the cultivars in Thailand and China are biennial bearing. Indonesian workers identified poor flowering as the major reason for low yields in longan trees growing in Java. This has occurred in Australia provided careful attention is paid to fruit pests.

In China, the average yields are 36 kg/tree in Fujian province and 18 kg/tree in Guangdong, equivalent to 5 to 10 t/ha at a density of 270 trees/ha. Longans are considered a poor proposition in Guangdong. This probably reflects the poor sites for growing trees in Guangdong, that is, shallow soils in hillsides and foothills, with no irrigation and little or no pest management.

Table 6. Average yields for trees of different ages in Taiwan

Year	10	20	30	50	70
Yield*	33	110	132	154	50
Yield**	9.9	7.7	9.2	10.9	3.5

* (kg/tree)

** t/ha at 300 trees/ha declining to 70 tree/ha at year 20)

A similar pattern of cropping to Thailand's and China's has emerged at Kamerunga and Maroochy Horticultural Research Stations.

Pests

Longan in Queensland is relatively free of pests as compared to lychee. However, the longan is at a disadvantage because trees flower and fruit later than most lychee cultivars, which are alternative host for many longan pests. Basically, the pest complex affecting the crop in southern districts is the same as that in northern Queensland, with some difference in the relative severity of some of the pests in the two environments.

The main insect pests attacking longans in Queensland are scales *(Chloropulvinaria psidii)*, aphids, stem borers, leaf eating beetles, flower caterpillars, mealybug, fruit spotting bug *(Amblypelta nitida* and *A. lutescens)*, stink bug, macadamia nutborer *(Crytophlebia ombrodelta)*, elephant beetles *(Xylotrupes gideon)* and fruit piercing moth *(Othreis fullonia* and *Eudocima salaminia)*. Effective chemical control is available for all but the last two pests. The only practical means of limiting damage from these two pests is to harvest the fruit as soon as possible.

Erinose mite *(Eriophyes litchii)* occasionally attacks young trees but seldom reaches serious proportions as in lychee.

In Asia, the fruit fly (*Dacus dorsalis*) is a serious pest on longan. However, in Australia the Queensland fruit fly (*D. tryoni*) is not attracted to longan or, if it is, the female is not able to penetrate the fruit skin.

Birds and flying foxes can cause serious losses in some seasons in Queensland. The only effective means of reducing damage is to erect a protective net around the perimeter of the orchard or over each tree. The cost of such netting is about A$4,000 to A$4,500/ha, with a life of 10 years.

Diseases

No major disease currently limits longan growing in Australia.

The only significant disease affecting longan in Asia is the Witches Broom mycoplasma which deforms the inflorescence and causes a loss of all flowers on an infected branch (the flowerless panicle resembles a broom). In severe cases, the leaves may also yellow and brown along the leaf veins and form blisters. The disease is present in longan orchards in China, Hong Kong and Thailand, although cultivars vary in their sensitivity to damage.

The mycoplasma is transmitted by seed, grafting, inarching or marcotting from diseased parent trees. None of the longan cultivars from China, Hong Kong or Thailand can be guaranteed to be free of the virus. Consequently, all longan material introduced into Australia should be closely examined for symptoms of the mycoplasma.

A black mildew affects late cultivars in Thailand (for example Baidum) causing a blackening of the skin and fruit abscission before harvest. The disease is exacerbated by the onset of the wet season and the size and compaction of the longan fruit branches. Effective control is normally possible with benomyl or copper oxychloride.

Weed control

Weeds in longan orchards reduce plant growth and vigour by competing with the trees for light, moisture and nutrients. In Australia, a volunteer grass cover is normally allowed to establish in the interrow area and weeds between the rows mown, and herbicides are used to kill weeds around the trees to a distance of 0.5 to 1.0 m.

Contact herbicides such as paraquat can control broad-leafed weeds and grasses in the early stages of growth, but persistent weeds (nut grass, couch grass or paspalum) require treatment with a systemic herbicide such as glyphosate.

Longan foliage and green trunks are damaged by non-selective herbicides such as paraquat and glyphosate. Avoid spraying in windy conditions and use fan nozzles and low pressure, large droplet sprays. Use shields on sprayers to minimise damage to trees. Rope wick applicators are available for applying glyphosate.

Domestic market potential

The potential market for longan in Australia is unknown. The fruit have a distinctive musky flavour and do not really taste anything like lychee or rambutan. Longans are readily accepted by most Asians with previous experience of it overseas. In fact, a significant proportion of Chinese and Thais rate longan as popular as lychee or more so. Most Australians would only acquire a liking for longans after several tastings. Small quantities of fruit have sold for up to A$12/kg on the Brisbane markets, but the unit price was too high and packaging uninteresting for many buyers to try them.

Longan fruit store longer than lychee at room temperature or under refrigeration with little dehydration, loss of colour or rotting. Fruit store well if quick frozen. Aril flavour, texture and colour are quite acceptable after thawing. Because of their tough leathery skin, longans transport well and are not readily bruised.

Although a long production season is possible for longan in Australia with the planting of a range of cultivars in a

range of environments, most fruit will be harvested during the late summer months in competition with a wide range of deciduous fruits. Demand for longan by ethnic Asians in Australia currently far exceeds supply and even seedlings have been acceptable to some extent. Production of better fruiting types with thick crisp sweet flesh and large size should satisfy ethnic population and stir the interest of Europeans.

Market development will depend on the availability of good cultivars, the continuity of supply, market presentation and promotion activities. The development of lychee in Australia will certainly help in establishing a market for longan, especially since longans mature after lychees.

Export market potential

Longans are a very popular summer fruit in Asia and are available from China, Taiwan and Thailand from June to September. Historically, China's crop was predominately processed as dried fruit (intact or with the skin removed). However, most of the crop is now eaten fresh or canned. The destination of the crop in an average season is: fresh 60%, dried 20% and canned 20%. Certain cultivars are eaten fresh, others canned or dried.

A considerable portion of the harvest in Thailand and Taiwan is canned at the peak of the season, but the fresh market is the most lucrative for growers. Longan fruit are usually canned in their own juice without the addition of sweeteners because of the high sugar content of the fruit (15 to 25%). Longan fruit retain their flavour better than lychee after heat sterilisation.

Fruit in Thailand in July 1985 were fetching A$1.05 to A$2.10/kg, depending on cultivar and quality. The preference is for large fruit (greater than 2.5 cm diameter or about 18 to 20 g) with small seed and sweet crisp flesh. For instance, cultivars Chompoo, Haew and Biew Kiew attract 20 to 40% more than cultivars such as Daw and Dang and twice the price of wild seedling types.

Thailand exports up to 50% of its longan crop in some seasons and longans are the most important export fruit crop. In 1984, for instance, it exported about 5.5% of its crop: 4200 t to Hong Kong, 4100 t to Singapore and 240 t to Malaysia. Significant quantities were also shipped to the Philippines, Japan, Canada, USA, UK, France, Netherlands and several Arab states. China and Taiwan also export substantial quantities of longans to Hong Kong.

Prices fluctuate considerably during the season. Early fruit may fetch A$3 to A$5/kg but, as supplies increase, the price drops to as low as A$0.40 to A$1/kg. Average prices for the 1984 season in Hong Kong, Singapore and Malaysia were between A$1.41 and A$1.56/kg. Singapore consumers pay more for Thai fruit because they are normally larger and sweeter than those from China or Taiwan. Retail prices for longans are about half those for lychees. We have no information on the prices expected for out of season longan in south-east Asia.

The Asian market must be considered a very promising area for longans grown out of season in Australia. There is no significant longan production in the southern hemisphere. Trial shipments of top quality fruit (both with or without stalks) in tray packs are warranted.

Research priorities

Most of the important cultivars from the major longan growing areas of the world have now been introduced into Australia. The better quality cultivars warrant evaluation for their cropping ability in a range of environments along the eastern coast of Australia. We do not have reliable yield records for mature trees. Trees in south-east Asia are usually strongly biennial bearing.

Although it is easy to propagate longans by air-layering or cutting, grafting is the preferred option in Australia. The yielding ability and wind resistance of trees propagated by different methods have not been critically examined.

Further work is required to define tree management techniques (irrigation, nutrition and pruning) that will reduce biennial bearing and increase fruit size. Many of the longan cultivars in Australia produce small fruit size. Only limited information is available on pollination and pest management.

Opportunities also exist for expanding grower returns if a postharvest technology could be developed to prolong shelf life.

Potential commercial development

Longan production in Australia should be developed to cater for both the domestic and export markets, since the former is limited in size. Because of the low prices paid for longans in South East Asia in the northern season, export markets outside Asia should not be ignored. If we are to successfully exploit the export market we must guarantee production and fruit quality.

No longan plantings of real significance are found in the southern hemisphere. In the northern hemisphere, only China, Taiwan and Thailand have substantial production. Several attributes of longan favour its commercial development in tropical and subtropical eastern Australia:

- trees are easily propagated
- they will grow on a range of soil types
- most pests can be readily controlled
- no major disease as yet
- low crop loss to postharvest diseases
- fruit not susceptible to fruit fly in Australia
- production available for 4 to 5 months in Australia
- postharvest technology readily developed with limited research effort
- fruit is consumed without preparation
- fruit is unique and exotic
- fruit is easily promoted (exotic nature and long history ofcultivation)
- fruit is packaged easily without damage
- fruit maintain quality fairly well after harvest
- fruit can be dried or canned
- good image possessed by canned fruit
- fruit is well known in Asia

- fruit can be identified by cultivar possibly to obtain premium prices
- fruit can be marketed out of season in south east Asia (price uncertain at moment!)
- there is no major competitor in the southern hemisphere
- the orchard has a long life.

Nevertheless, there are certain limitations:

- some cultivars are susceptible to biennial bearing and small fruit if not carefully managed
- trees are moderately susceptible to environmental stresses (wind, frost, high temperatures, low humidity and salinity)
- cropping technology is not fully developed
- high cost of harvesting and packaging
- fruit may require cool storage after harvest
- product is unknown locally by most consumers
- lack of buyer confidence in fruit quality (agents, retailers and consumers)
- competition with other summer season fruit
- the unknown price of fruit on export market
- factors affecting profitability are not defined.

Conclusion

The demand for Australian grown longans locally and in overseas markets has yet to be fully evaluated. Intending growers should also be aware that no firm varietal or cultural recommendations are yet available for this crop in Australia. Growers should assess these risks before embarking on large scale commercial longan cultivation.

Acknowledgements

Information on longans by Don Batten, Chau Kay-ming, Colin Bock, Keith Chapman, Gordon Vallance, Geoff Waite and Ted Winston is gratefully acknowledged. We thank Cathie Menzel, Keith Chapman, Ken Robinson and Russ Stephenson for review of the manuscript.

Further reading

Batten, D.J. (1986b), 'The longan', Australian Horticulture, **84**, 14-32.

Chapman, K.R. (1984), *Tropical fruit cultivar collecting in south east Asia and China,* pp. 123.

Watson, B.J. (1980), 'Longan fruit', *Queensland Fruit and Vegetable News*, January 24th, pp. 59-62.

Watson, B.J. (1984), 'Longan' in *Tropical Tree Fruits for Australia,* Queensland Government Printer, Brisbane, pp. 192-197.

Winks, C.W., Batten, D.J. and Burt, J.R. (1983), *Australian subtropical horticulture mission to the Peoples Republic of China, Commonwealth Department of Primary Industry,* pp. 75.

Winston, E. and O'Farrell, P. (1989), 'Performance of longan *(Euphoria longan)* on The Atherton Tableland of north Queensland', *Newsletter of the Rare Fruits Council of Australia*, **55**, 3-8.

Ordering QDPI books

Handling charges, including postage

	Australia surface $	Overseas surface $
0-100 g	1.50	3.00
100-250 g	2.50	4.00
250-500 g	4.00	6.00
500 g-2 kg	7.50	16.00
2-5 kg	9.00	25.00
5-10 kg	10.00	40.00
10-20	15.00	70.00

Airmail rates are available on request.

One of the roles of a meat inspector

R.L. Domjahn, Veterinary Public Health Branch

Recently, routine meat inspection procedures at a slaughtering establishment detected a parasitic infestation of lamb carcasses so severe that a large percentage of the affected carcasses were condemned. The lambs had been purchased in New South Wales and transported to Queensland by road.

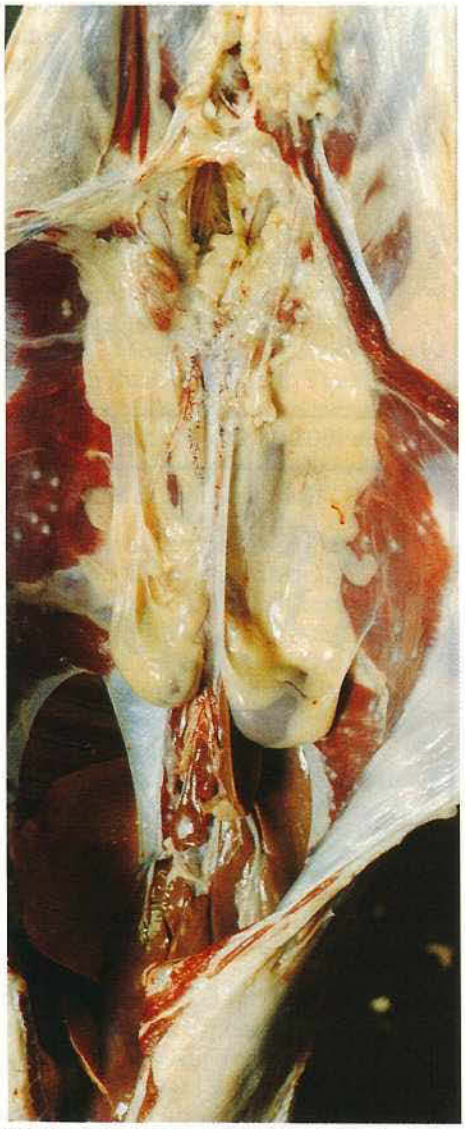


Plate 1. Cysts on internal flank area and diaphragm.

Details of the lambs' origin were noted and passed on to the NSW authority, so they could instigate traceback and control measures on the property of origin.

The parasite sheeep measles, (*Cysticercus ovis*) is the cystic or larval stage of the tapeworm *Taenia ovis* which can infest dogs and foxes. It is spread by mature segments of tapeworm being passed in the dog or fox faeces. The segments, which contain numerous eggs, contaminate the pasture, and when these eggs are ingested by the sheep, the larval stage of the life cycle begins.

The eggs hatch in the sheep digestive tract, burrow through the wall of the intestine and make their way to various locations such as the heart muscle, diaphragm, tongue and cheek muscle, where they form into cysts.

Infestation is usually first detected by an inspector, but in the case under mention many of the carcasses were so heavily infested that the cysts were present throughout the entire carcass.

The cyst appears as a semi-opaque whitish lump approximately 7 mm in diameter. Each cyst contains a tapeworm head. When mature cysts are eaten by a dog or fox, they may develop into the adult tapeworm in the intestine and so the life cycle continues.

Although the parasite cannot affect humans, it is of significant economic importance to the meat industry because affected carcasses are rejected from certain markets and frequently condemned.

In this case, approximately 30% of the mob were condemned. The importance of a meat inspector's duty in detecting and reporting instances of disease such as this demonstrates the necessity of continuing co-operation between QDPI and primary producers.

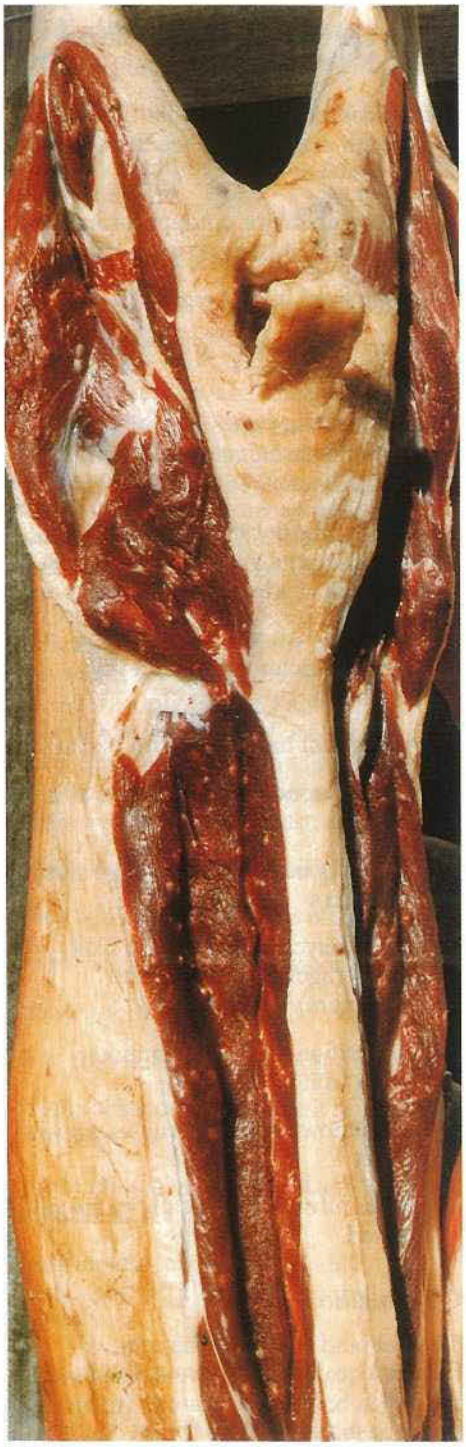


Plate 2. Cysts in all the carcass muscles.

Protein in milk: 'true' versus 'crude'

G.E. Mitchell, Food Research and Technology Branch

Increased emphasis on the nutritional importance of high protein products has led to interest in including protein in milk supplier payment schemes. However, in discussing protein levels in milk it is important to distinguish between 'true' protein and 'crude' protein.

Milk protein

Protein in milk is part of the portion called solids-not-fat (SNF). The SNF includes everything in milk except fat and water (figure 1).

Milk protein consists of two major fractions — caseins and whey proteins (figure 1). Most of the protein in coagulated products such as cheese and yogurt is from the casein fraction which forms the curd; the whey proteins are still soluble when the curd is formed and are lost in the whey.

Milk protein levels vary with the animal, its nutrition and the environment. Protein levels in milk generally reflect the overall level of nutrition. An adequate supply of energy, obtained from concentrate-type feeds and good quality roughages, generally ensures satisfactory protein levels. A shortage of energy, caused by excessive dependence on low quality roughages, tends to depress protein percentage. In Queensland, the protein content of milk tends to decline in spring and autumn, the periods of greatest nutritional stress.

True versus crude protein

Protein is made up of amino acids, which contain nitrogen and give protein its characteristic high level of nitrogen. This characteristic is the basis for the chemical measurement of protein in the laboratory.

In the chemical test (which is the reference method) for protein, it is the nitrogen that is actually measured. The amount of nitrogen is then multiplied by a factor to convert it to an amount of protein. It has been established that the

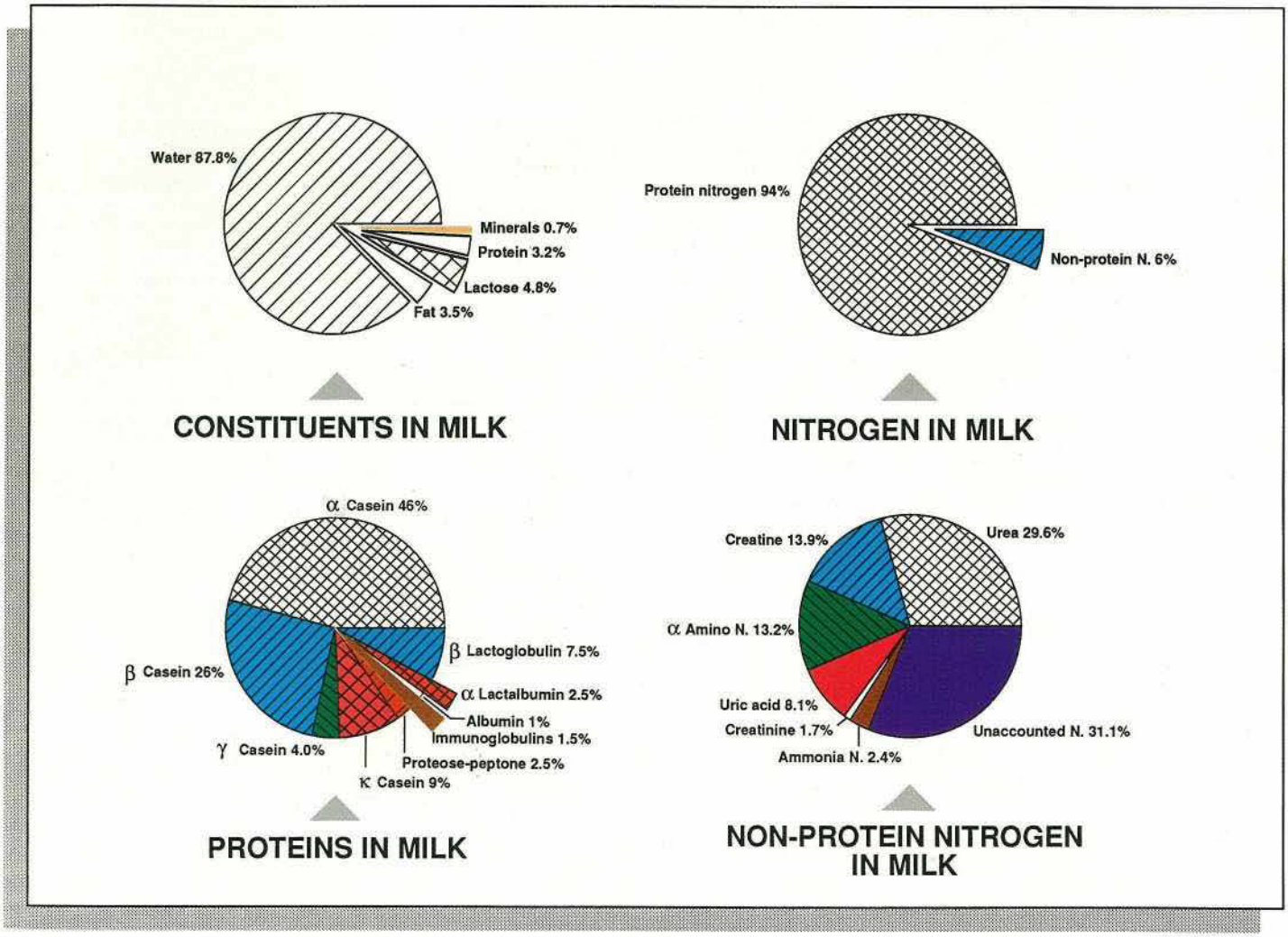


Figure 1. Average proportions of various constituents in milk. (N = nitrogen)

proportion of nitrogen to total protein in milk is 1 to 6.38, or 15.67%. Hence, the factor for converting nitrogen to total protein is 6.38%.

Because the chemical test for protein is really a measurement of nitrogen, the test result is affected if there is nitrogen present from a source other than protein. As can be seen from figure 1, approximately 6% of the nitrogen in milk is from non-protein type compounds. These compounds have little nutritional importance, that is humans cannot use them as a source of essential nitrogen in their diet. The nitrogen present in these compounds is referred to as non-protein-nitrogen (NPN).

As mentioned above, the usual methods for measuring protein are based on the measurement of nitrogen and are not able to distinguish between protein nitrogen and NPN. Measurement of the total nitrogen present in milk then, and the use of the factor 6.38, gives rise to what is termed 'crude' protein. The term 'crude' protein is therefore the collective term used to describe all the nitrogen-containing substances in milk. It is a misleading term, because it includes substances that are not protein.

It is possible to measure NPN separately. When this is subtracted from the 'crude' protein, the result is called true protein. In milk then, true protein consists of the caseins and whey proteins, the only nutritionally useful components.

It is important to understand the difference between true and crude protein. For an average protein content of 3.3% crude, about 0.18% would be NPN, with only 3.12% true protein.

In summary

Crude protein nitrogen = true protein nitrogen + NPN

Non-protein-nitrogen

The NPN constituents shown in figure 1 are known to be the end products of nitrogen metabolism in the animal's body and are presumably introduced into milk directly from the blood. The amount in milk varies with the individual animal, the breed, and the feed being consumed. There is little change in NPN levels due to season of the year.

The unaccounted for nitrogen in figure 1 would include such compounds as hippuric acid, orotic acid, indican, phosphoglyceroethanolamine, o-phosphoethanolamine and phenyacetylglutamine.

Measurement of true protein

Milk testing instruments commonly used in the dairy industry measure only true protein. They do not measure NPN-containing substances. This applies to both infra-red and dye binding instruments.

However, these milk testing instruments are usually calibrated to give crude protein values. The conversion factor required to give crude protein values from true protein measurements is an arithmetical factor which does not vary once an instrument has been calibrated. Therefore, differences in NPN-containing substances are not detected.

In order to obtain true protein values from these instruments it is only necessary to ensure that calibration standards are measured in terms of true protein nitrogen. This involves two nitrogen determinations (one for total nitrogen and one for non-protein nitrogen) to be carried out by the reference chemical method.

Advantages in measuring true protein

The measurement of true protein offers several advantages to the dairy industry:

- for most manufactured dairy products, true protein correlates more closely with product yield than crude protein
- true protein in milk is more reliable than crude protein as an indicator for breeding improvement programmes because true protein correlates more closely with breed and genetic change
- true protein is the nutritionally valuable component
- milk testing instruments commonly used in the dairy industry do not measure NPN-containing substances — they give identical results for milks with different crude protein but the same true protein contents.

Weaner management in north-western Queensland

B.M. Burns, M.T. Sullivan, and **P.C. Smith,** Beef Cattle Husbandry Branch

Introduction

North-western Queensland can be divided into four general areas: the more fertile cracking clay soils of the Mitchell grass downs; the less fertile clay soils with blue grass, brown top grasslands of the gulf lowlands; the less fertile forest country mainly to the east of these clay soils; and the lowly productive mountains and ridges of the Mt Isa highlands. The poor nutritive value provided by the native pastures in these less fertile areas in north-western Queensland results in low breeder fertility, poor growth rates, high death rates and low female cattle sales.

Poor nutrition during lactation suppresses reproduction in Brahman and Brahman crossbred breeders. However British breed cattle can often die. The condition is known as lactation anoestrus. More calves can be produced if the nutritional requirements of such cows are reduced.

Weaning removes the stress of lactation. Some, or all of the following responses can result depending on age at weaning and seasonal conditions at the time:

- improved breeder condition
- reduced breeder death rates
- reduced drought stress
- improved branding rates
- improved sale value of cull or drought affected breeders.

The recommendations advanced in this article are drawn from the experiences of both departmental beef cattle husbandry officers and producers in north-western Queensland.

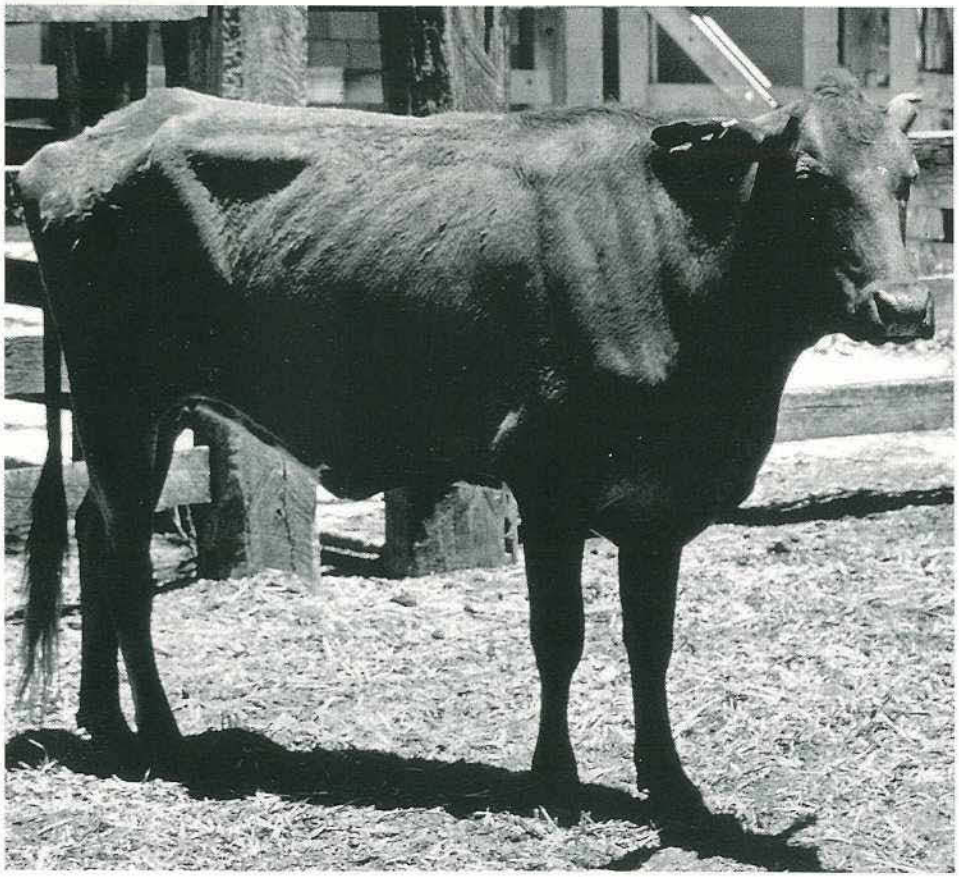


Plate 1. Lactating breeders, which suckle calves during the dry season are survival risks.

Weaning strategies

A recent development in northern Australian cattle herds is to wean calves at younger ages. In the past, calves were normally weaned from 6 to 10 months of age. At present, some calves are routinely weaned to 6 weeks of age. Further, because of the severe drought conditions experienced in north-western Queensland during 1988, some calves were successfully weaned to two weeks of age.

The consequences of this radical weaning practice (less than three months of age) were:

- cows were agisted alone, hence a further weaning muster was not required after arrival at agistment; and
- supplement requirements and costs were reduced as only calves were fed.

Weaner management

Age at weaning governs level of weaner management. Factors which determine age at weaning include season, stage of property development and male turn-off age.

In the past, high weaning rates were not critical when bullock turn-off age was four years of age and older. Today, higher breeder fertility and weaner survival rates are required because market pressures demand younger ages of turn-off. This can be achieved in Brahman and Brahman crossbred herds in poor nutritional areas by weaning calves to three months of age at two musters each year.

Some suggested husbandry practices to reduce stress in weaned calves are:

- separate smaller and weaker calves from larger and stronger ones to reduce bullying at feeding times
- feed calves from the day they are weaned
- keep feeders and troughs up off the ground
- feed hay in racks or round bale feeders to prevent waste

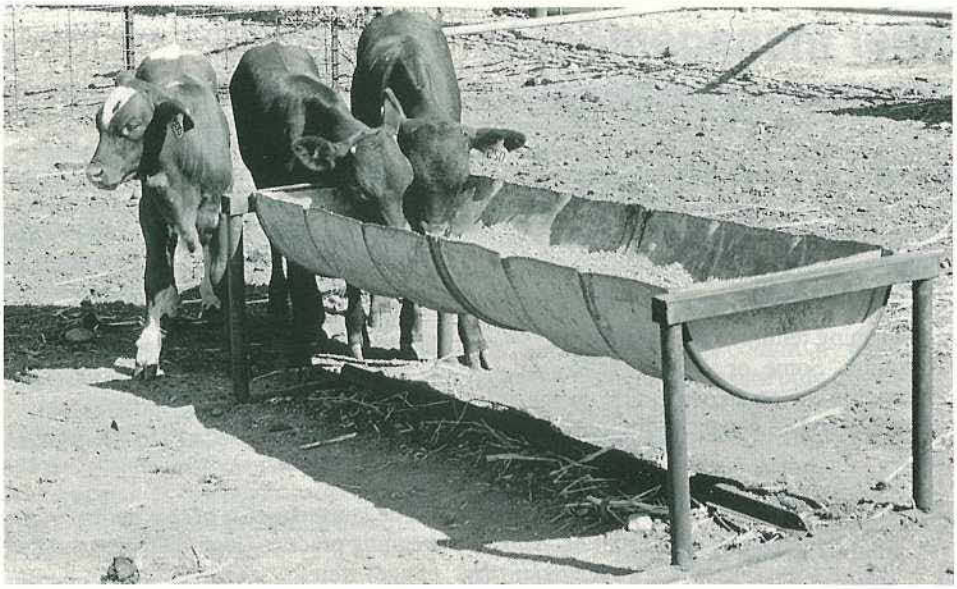


Plate 2. Calves feed weaner pellets from a home-made feeder up off the ground.

- feed protein meals twice a week
- do not stop supplementation or change feed suddenly. Calves should be eased off one supplement and onto another or eased off a supplement onto pasture
- clean water should always be available
- do not brand, earmark, castrate or dehorn until the calves leave the yards
- draft off sick or weak calves and manage them as a hospital group
- educate the weaners
- use 5 in 1 vaccine where disease is a problem
- drench calves if worms are considered a problem
- Rumen modifiers such as Rumensin and Avoten can improve the efficiency of feed conversion. Rumensin is also known to have coccidiostat properties
- watch for signs of lice and ticks on the calves and treat immediately if necessary.

Weaner education

During the 10 to 14 days the weaners are in the yards they should be worked quietly through the yards and crushes. Further, they should be 'tailed out' a number of times towards the end of the weaning period (plate 3).

Weaner education is one of the most important management strategies on any property. Properly educated weaners will be quiet and easy to handle in yards and during mustering. They will also bring premium prices when they are sold.

Weaner supplementation

The younger a calf is weaned the higher the ration quality needed to reduce the setback caused by weaning. Feeding the right supplement at the recommended level will minimise the stress of weaning and result in a well grown weaner ready for rapid growth from the start of the wet season.

Calves should be divided into the following groups according to age and liveweight to ensure the best results from a feeding program (table 1).

Radical weaned calves under 3 months

Weaning at less than 3 months of age is not usually recommended, but it was common in the Gulf Shires during the 1988 drought. In one case, where breeders had stopped lactating and were dying, calves between 2 weeks of age and 6 weeks of age were successfully weaned and fed.

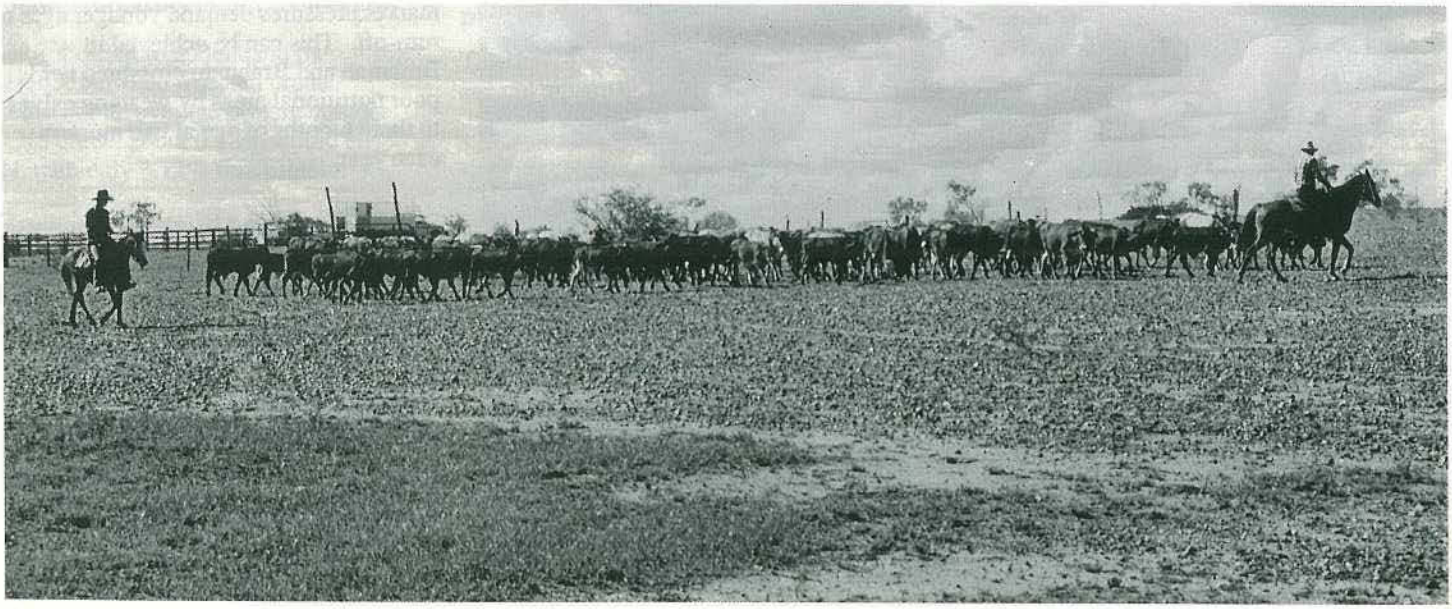


Plate 3. Tailing out calves is an essential part of any management strategy and results in more manageable cattle.

Calves 2 to 6 weeks of age

This group should be fed a high quality, easily digestible calf meal containing at least 18% crude protein. Commercial preparations are available. Alternatively, a home made meal can be made up by mixing four parts by weight of coarse cracked grain with one part of protein meal such as cottonseed meal, meatmeal, sunflower meal or soybean meal. These calves should be given unrestricted access to the meal and they should also have access to 1 kg/day of good quality, fine, leafy hay.

Calves 6 to 12 weeks of age

This group of calves can be fed commercial calf weaner pellets at the rate of 1 kg/head/day. They should also be given access to good quality, fine, leafy hay.

Calves weaned at less than 3 months of age are effectively single stomached animals, because the ruminant digestive system is not fully developed. Fibre from the hay stresses the rumen and encourages more rapid development of the digestive system. Thus, the calves are able to use high fibre diets at a younger age.

The target daily liveweight gain of calves less than 3 months of age is 300 g/day.

Early weaned calves - 3 to 5 months of age

Weaning down to 3 months of age twice a year (in the April/May and August/September periods) is being promoted as a management practice to increase breeder productivity in the drier extensive areas of north and north-west Queensland.

The increase in breeder productivity from this early weaning strategy results in improved breeder body condition; hence, conceptions and weanings increase, death rates are reduced and overall herd sales, especially of females, increase.

Weaners of 3 to 5 months of age require a high plane of nutrition for satisfactory growth. They should be fed a high protein supplement from the day they are weaned. The protein supplement can either be fed alone or in combination with molasses.

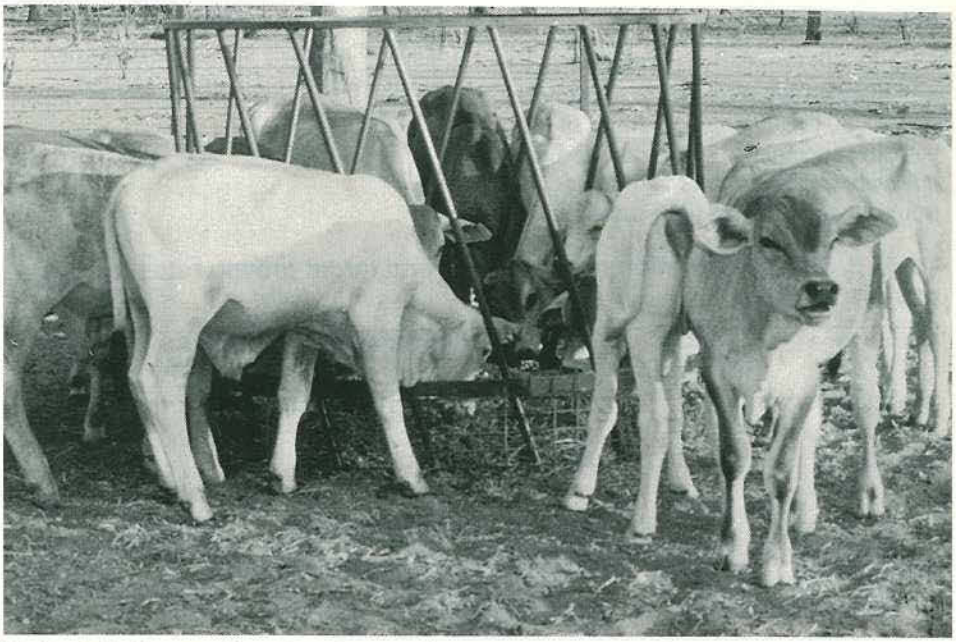


Plate 4. Calves eating hay from a Parson's round bale feeder, which prevents spoilage and waste.

Meat and bone meal and cottonseed meal are good protein supplements when fed at the rate 500 g/head/day. However, meat and bone meal is not very palatable, and there may be some acceptance problems with it at first.

When protein meals are fed alone they should only be fed once or twice per week. More regular feeding leads to the stronger calves getting more than their share. As a result, a 'tail' soon develops on the group.

If molasses based supplements are used the calves should have unrestricted access to them at first, as extended periods without supplement depresses animal performance. Weaners of 3 to 5 months of age can maintain liveweight on a molasses/urea ration; however, the addition of protein meal is required for liveweight gain. When urea is added to molasses supplements, mechanical mixers should be used.

While the calves are in the yards they should be fed 1 kg head/day of hay as well as a protein supplement. However, once they leave the yards they should be placed onto good quality pasture with a protein supplement provided.

The target daily liveweight gain of this age group of calves is 200 g/day.

Normal weaned calves: over 5 months of age

Weaners over 5 months of age can cope with reasonably harsh conditions. However, to ensure that they maintain liveweight a minimum supplement of 2 kg/head/day of molasses plus 8% urea (M8U) is needed. The addition of a protein meal to the M8U will ensure better performance. If you do not wish to use a molasses based supplement, cottonseed meal or meat and bone meal can be fed at the rate of 500 g/head/day.

Forage sorghum hay or good quality hay should be fed at the rate of 1 kg/head/day with a protein supplement while the weaners are in the yards.

The target daily liveweight gain of this age group of calves is 100 g/day.

Table 1. Class, age and weight of weaner calves

Class	Age	Weight
Radical weaned calves	less than 3 months	less than 100 kg
Early weaned calves	3 to 5 months	100 to 150 kg
Normal weaned calves	more than 5 months	more than 150 kg

Feeding space

Care should be taken to provide sufficient trough space for all calves to eat at once. About 250 to 300 mm of feeding space per calf is adequate if calves are fed from one side of the trough or 150 mm of trough space if calves have access from both sides. Some calves may be 'shy feeders' and they should be identified, drafted off the main group and fed separately.

Conclusion

Feeding the appropriate supplement at the recommended level coupled with astute husbandry practices minimises the stress of weaning and ensures a well grown animal ready for rapid growth when the wet season commences.

Table 2. Supplementation requirements and target growth rates for different weaner age groups grazing different pasture qualities

Age of weaner	Growth rate	Good quality grass (13% CP)*	Supplement requirement	Poor quality grass (<5% C.P.)	Supplement requirement	'Nil grass'	Supplement requirement
2-4 weeks (<50 kg) Crisis	300 g/d	• 4 parts grain to 1 part protected protein** • calf meal (18-20% CP)	1 kg/hd/day				
		• plus good quality lucerne hay	1 kg/hd/day	→	→	→	→
6 weeks-3 months (<100 kg) Radical	300 g/d	• 4 parts grain to 1 part protected protein • calf weaner pellets (16-18% CP) • molasses + 3% urea + 8-15% protected protein • molasses + 8-15% protected protein	1 kg/hd/day	• 4 parts grain to 1 part protected protein • calf weaner pellets	1 kg/hd/day	→	→
		• plus good quality forage sorghum or lucerne hay initially	1 kg/hd/day				
3-5 months (100-150 kg)	200 g/d	• protected protein • molasses + 8-15% protected protein • molasses + 3% urea + 8-15% protected protein	0.5 kg/hd/day 1 kg/hd/day 1 kg/hd/day	→	→	• grain + protected protein • molasses + 3% urea + 8-15% protected protein • plus good quality roughage	1.5 kg/hd/day 2 kg/hd/day 1 kg/hd/day
>5 months (>150 kg)	100 g/d	• urea as 'dry lick' • urea/molasses/water in roller drum • urea based blocks	30 g urea/day 30 g urea/day 30 g urea/day	• protected protein • molasses + 8% urea (M8U)	0.5 kg/hd/day 1 kg/hd/day	• grain + protected protein • molasses + 8% urea • molasses + 3% urea + 8-15% protected protein • plus good quality roughage	1.5 kg/hd/day 2 kg/hd/day 1.5 kg/hd/day

* PC = crude protein
**Protected protein = cottonseed meal or meat and bone meal
< = less than
> = more than