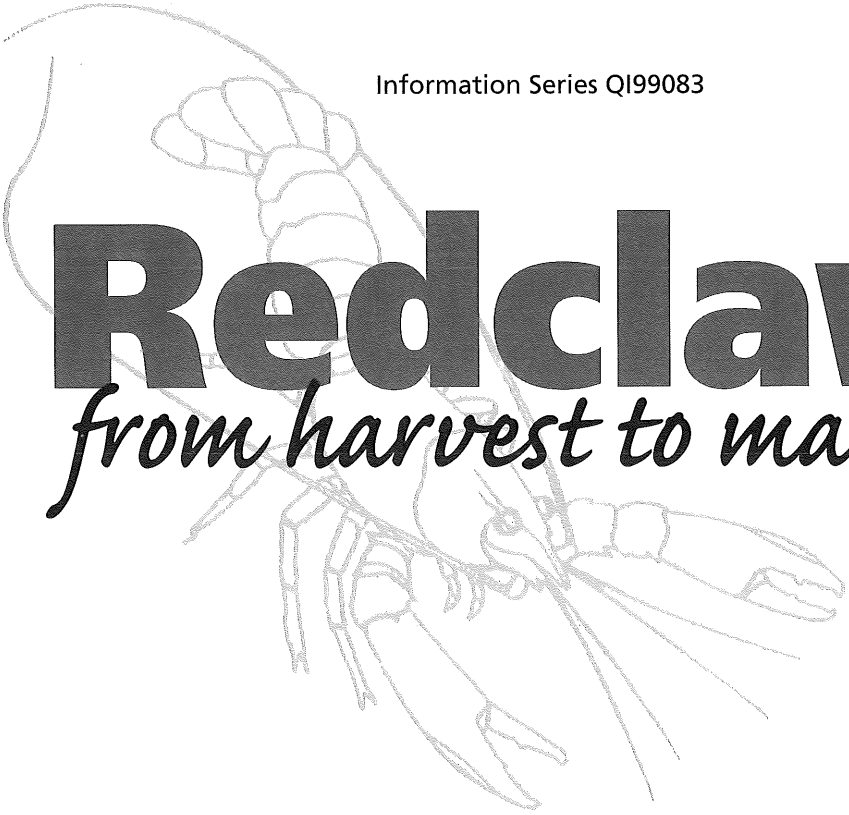


Information Series Q199083



Redclaw

from harvest to market

A manual of handling procedures

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Queensland

ISSN 0727-6273
Q199083
Agdex 472/70

First published 2000

Jones, Clive M.

Redclaw from harvest to market: a manual of handling procedures.

Bibliography.

ISBN 0 7345 0069 6.

1. Crayfish industry. 2. Crayfish. 3. Crayfish culture.

I. Grady, Jo-Anne, 1964-. II. Queensland. Department of Primary Industries.

III. Title. (Series: Information series (Queensland Department of Primary Industries); Q199083).

639.54

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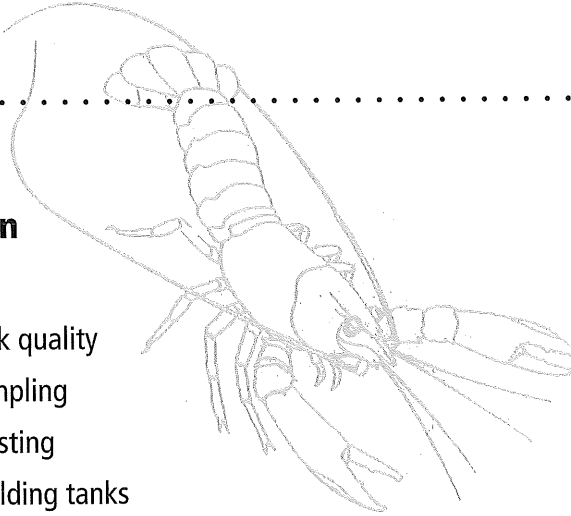
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1 Introduction

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Optimising the quality of redclaw for the market is dependent on many factors throughout the production chain. Poor farming or handling practices at any time from juvenile production through to harvesting of market size stock may be reflected in poor quality product or high levels of mortality during live transport. Optimising quality of product during post-harvest processes therefore cannot be isolated from farming methods. Quality assurance procedures should begin at the initial stages of production. However, the converse is also true, and post-harvest procedures should ensure that harvested stock is maintained at high quality until it reaches its market destination and the consumer.

Redclaw are perceived as being an extremely 'forgiving' animal in that they are physically robust, tolerant of poor conditions and easily kept alive. It is true that they possess broad environmental tolerances and can survive exposure to air. However, reliance upon these attributes has limited the development of technologies that would optimise the quality of live redclaw or provide alternative non-live products. The existing industry is heavily reliant on live sales, which have been negatively affected by poor survival during and after transport.

Despite their perceived physical toughness redclaw, like all intensively managed livestock, suffer from stress imposed by harvesting, grading, packaging and transportation. High levels of mortality are frequently reported, particularly for the several days immediately after they reach their destination. There is a range of possible causes of mortality during and after live transport and further research is required to clarify them. It is clear however, that many of the procedures employed by farmers in arranging live transport are inconsistent and/or inappropriate. There is no fixed recipe for success, but by following the guidelines set out in this manual, producers should minimise mortality of live product and give further consideration to marketing frozen, chilled and cooked/chilled products.

It is important that producers, wholesalers and buyers of live redclaw acknowledge that specialised handling techniques are necessary and that a range of alternative products for processed redclaw may have equal or better market opportunity.

Harvesting has been included in these recommended procedures because it has such important bearing on subsequent product quality. Sections which follow include holding stock, grading and purging, treatment of unattractive product, flavour enhancement, transport methods for live redclaw and processing of killed redclaw.

2 Harvesting

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The health of the redclaw population, the water quality of the pond before harvest and the harvesting process itself will all contribute to the quality of product to be presented to the customer. All farming and handling practices affect final quality.

2.1 Water and stock quality

- There should be no recent history of mortality or disease in the pond.
- Ponds that have a current or recent bloom of blue-green algae should not be harvested for market until the bloom has been controlled. The algae appear as a green scum on the surface, usually blown into one area. As they die and dry out the slick may appear blue around the edges. Blue-green algae can be responsible for 'off' flavours in fish and crustaceans and, at worst, produce toxins which are harmful to humans as they break down. Thorough purging will clear the toxins from the redclaw.
- The pond population should consist of a high proportion at the desired market size. This can be determined by sampling prior to harvest (*see Pre-harvest sampling 2.2*).
- Redclaw to be harvested should be clean and marketable. This can be determined by sampling prior to harvest. It may be possible to treat some specific problems (*see Pre-harvest sampling 2.2 and Specific treatments 6*).

2.2 Pre-harvest sampling

- Baited traps may be used, but tend to select only the largest and healthiest redclaw therefore giving a false impression of the entire pond stock. Also, berried females are reluctant to move into traps and therefore won't be adequately represented by this sampling method.
- It is preferable to retrieve redclaw from the shelters which should be present already in the pond. Mesh bundles and pipe stacks with mesh backing are ideal as sampling-friendly shelters (see Figure 1).

2.3 Flowtrap harvesting

- Harvesting by flowtrap is the most labour- and time-efficient method. Redclaw respond to a current directed down the flowtrap ramp by walking against the flow. They are trapped in clean, well-aerated water without prolonged exposure to sun and air or predators (see Figure 2).
- Redclaw that are collected by hand from pond sediments are likely to suffer respiratory stress as their gills may become clogged with sediment. This is also

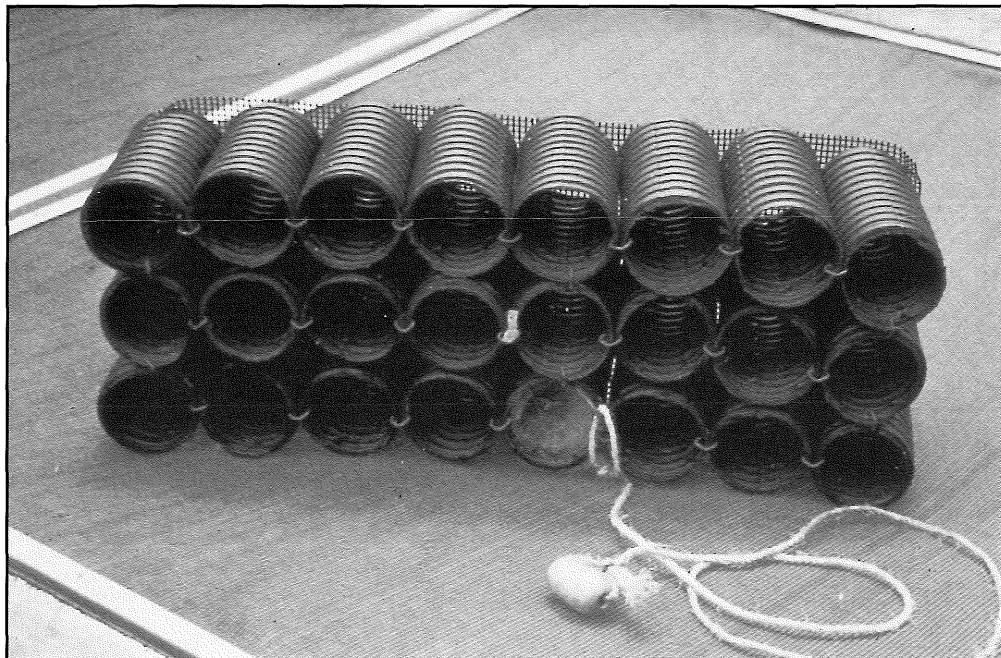


Figure 1. Pipe stack or mesh bundle shelters with float lines provide an easy method for sampling stock from the pond.

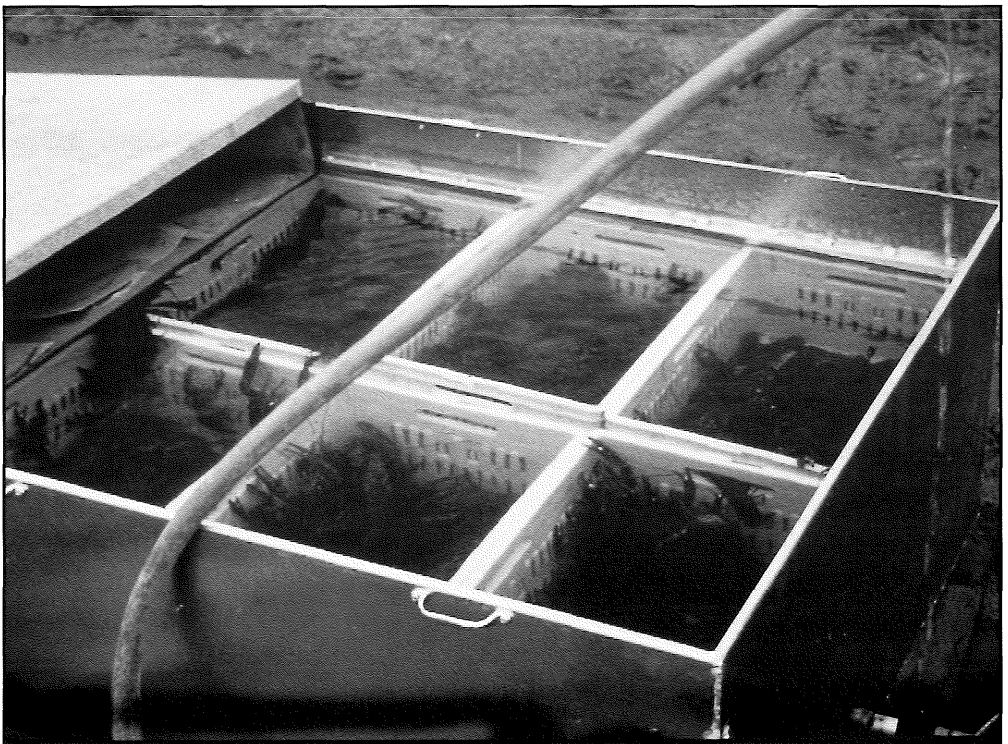
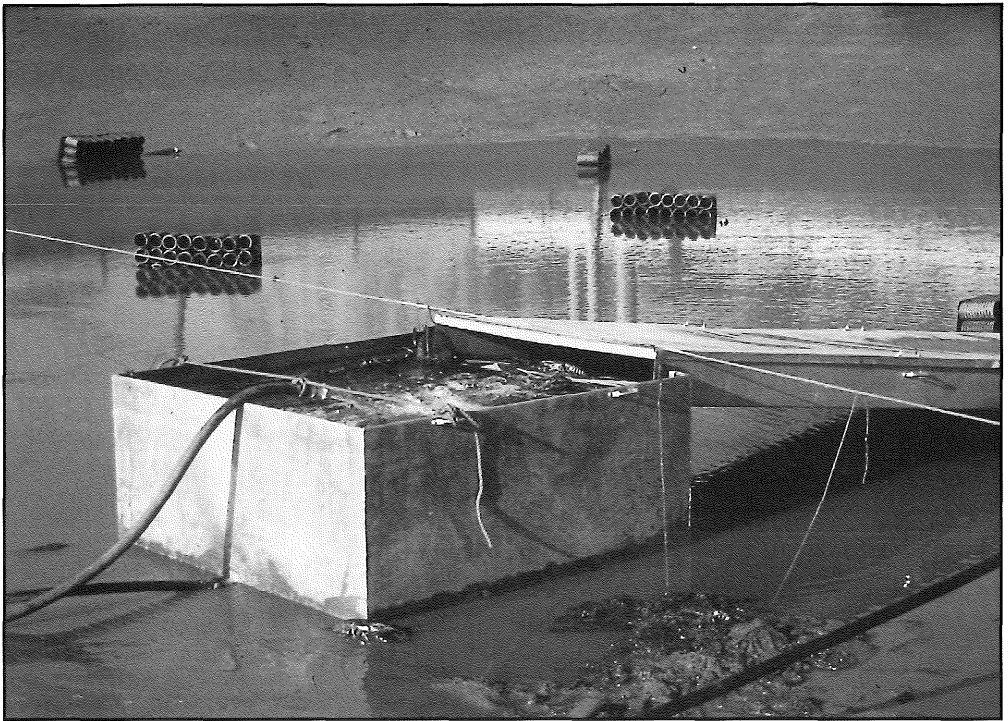


Figure 2. *Harvesting with a flow trap is labour efficient and results in high quality product housed in good quality water. This flow trap is equipped with plastic crates to facilitate easy removal of stock.*

likely to allow the proliferation of harmful bacteria on the gill surface. Any crayfish which are collected from the mud will need to be washed and placed in clean water as soon as possible, to remove sediment from the gills.

- The water source for the flowtrap should be of excellent quality and from a source other than the pond being harvested, to ensure that crayfish are not stressed in any way and that the trap is most effective. Poor handling or water conditions during harvest will affect the survival and quality of product.
- Partial harvesting of a pond using a flowtrap can be achieved. If the water level in the pond is not dropped, only a proportion of crayfish will respond.
- Harvesting by drainage alone is not recommended. All product ends up in dirty water with serious implications for product quality. Furthermore, the process is labour intensive and inefficient (see Figure 3).

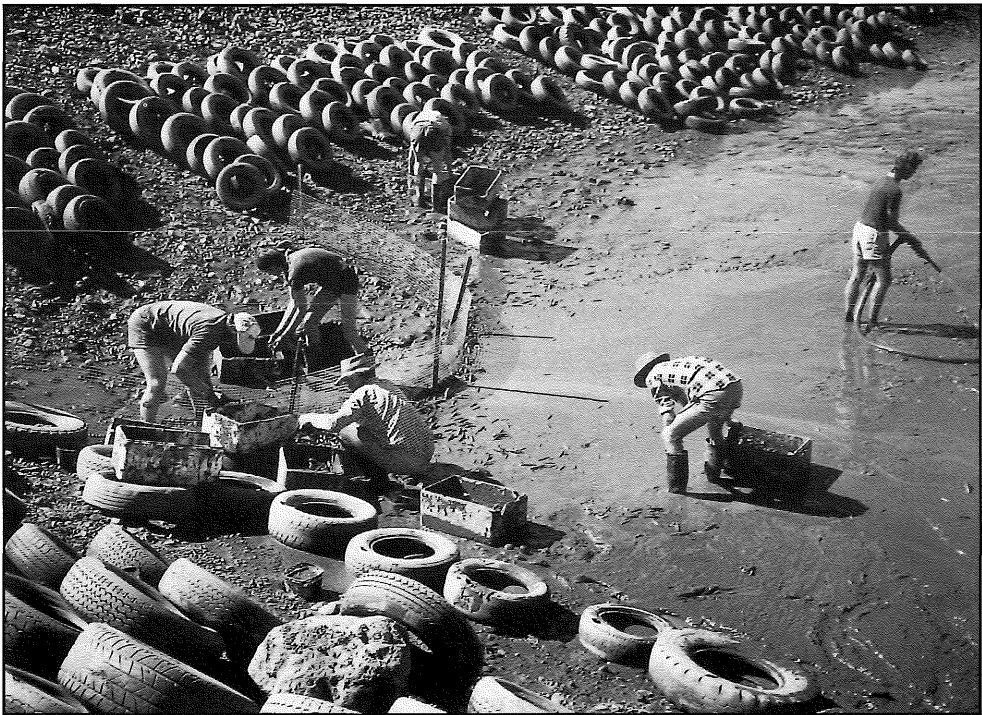


Figure 3. *Harvesting by draining the pond and manually gathering stock is inefficient, and results in poor quality product.*

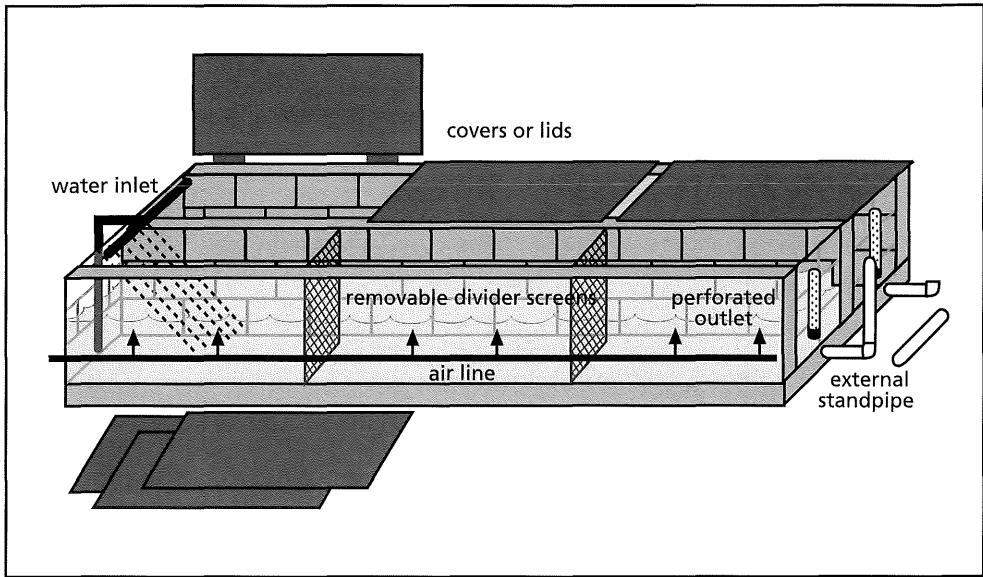


Figure 4. *Diagram of a flow-through raceway constructed from sealed concrete blocks. Features aeration line, spray bar water inlet and the flexibility of removable dividers.*

2.4 Transport to holding tanks

- Transport harvested redclaw to holding tanks as quickly as possible.
- Avoid crushing by limiting the number of redclaw in each container.
- Redclaw should be transported moist but not submerged in water. Transportation water holds only a limited quantity of oxygen and if crowded, the crayfish will rapidly use all of this oxygen resulting in deaths by asphyxiation.

Note: In the case of berried females being kept as broodstock it is recommended that they be transported in water between tanks or ponds to minimise damage to the eggs. However, water must be aerated during transport and should hold only a low density of redclaw.

- Speed of harvesting should never compromise care of handling.

3 Holding Redclaw in tanks

3.1 Tank design

- Tanks should be dark, covered, secure and predator-proof.
- They should be constructed of non-toxic materials (avoid metals) which can be effectively cleaned. Suggestions for materials include water-proofed concrete or masonry block, plastic or fibreglass, assembled with PVC or poly plumbing.
- Very rough surfaces should be avoided as redclaw may be damaged, and such surfaces may sustain elevated bacterial levels. Even small abrasions caused by rough surfaces may provide an entry site for bacteria which may defeat the immune system of a stressed animal. Rough surfaces are also difficult to clean.
- Redclaw may benefit from the provision of shelters within the holding tanks in order to minimise stress, however care must be taken that the type of shelter used does not allow either dead zones of water to surround the redclaw or the retention of faeces.
- Tanks should be of an adequate size and number to contain a full 1 000 m² pond harvest of up to 600 kg. Fortunately, redclaw can be held in quite crowded conditions for short periods as they are relatively non-aggressive. It is critical however, that excellent water quality is maintained at all times within the tanks. This will become more critical as the volume of redclaw being held increases. An inexpensive and flexible design is a concrete raceway with moveable mesh partitions which can be inserted to create smaller enclosures as grading requirements change.
- Circular or raceway designs minimise dead zones of water movement.

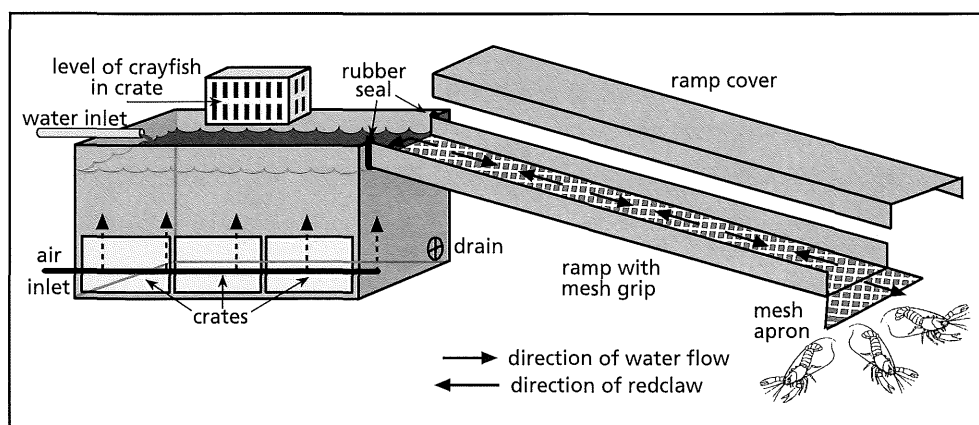


Figure 5. Diagram of a redclaw flowtrap. An information video explaining flowtrap harvesting is available from the Freshwater Fisheries and Aquaculture Centre, Walkamin.

3.2 Minimise holding period

- Although the length of time that redclaw can be held successfully without undue levels of mortality will depend on the condition of the animals after harvest and the water quality of the tank system, it is recommended that redclaw destined for live transport not be held in tanks for extended periods. Stress and lack of food for longer than one week will reduce the condition of the redclaw, resulting in mortality as they are subjected to further transport and packaging stresses. Ideally, redclaw should be held for no longer than 72 hours as increased mortality will occur following re-immersion after transport.

3.3 Avoid feeding

- Feeding redclaw in holding tanks should be avoided.
- If it is necessary to hold redclaw in tanks for longer periods, it will be necessary to feed them every few days to maintain condition and health. Feed used should be non-disintegrating and remaining waste should be easily removed. Potatoes, lupins, liver and squid are all suitable for short periods in tanks. Pellets should be avoided, unless they are particularly water-stable. It is important not to overfeed as water quality will deteriorate rapidly. Uneaten food should be cleaned out daily. All feed should be withheld and the tanks scrupulously cleaned for purging at least 24 hours prior to processing or sale (*see Purging 5*).

3.4 Maintain water quality and cleanliness

- Redclaw are reasonably gregarious and will tolerate being crowded in holding tanks. The system should be capable of maintaining excellent water quality when redclaw are held in densities of up to 250 grams of redclaw per litre of water. The capability of the system will depend upon either the amount and quality of flow-through water or the design and filtering capacity of the recirculating system.
- Aquatic animals, including redclaw, have an increased respiration rate when under stress, and therefore an increased requirement for oxygen. All holding tanks should have abundant aeration at all times.
- If redclaw have been removed from the sediments of the pond during harvest they will be muddy and that will affect the ability of the gills to transfer oxygen. Furthermore, it may pollute the holding tanks. They should be hosed or dunked in clean water to remove any mud as soon as possible after harvesting, and should not be placed in holding tanks until they are clean.
- Suitable water sources include rain water, bore water which has been aerated prior to use, or clean river or stream water.
- Water in holding and purging tanks needs to be either flow-through (continuously replaced) or recirculated through a biological filtration/treatment system (*see Appendix 1*).

4 Grading

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4.1 Keep redclaw cool

- Cool redclaw are less active and are therefore easier to handle and less subject to stress. For larger farms, an air-conditioned grading and packing facility may be a necessity. For smaller farms, where air conditioning is not economical, equivalent facilities should be kept as cool as possible and grading should occur in the morning, especially during summer in hotter regions. The preferred temperature of the air and water in the grading area should be between 15 and 18°C.

4.2 Maintain quality standards

- Redclaw should be graded by weight to suit market orders and to meet industry quality standards. Criteria for grading for market include size, condition and colour. Clearly, slow, soft, unattractive or sick redclaw should be excluded, or assigned to a specific low quality grade.
- Size grades are usually based on weight (rather than length), and may differ among markets and their specific customer preferences. Grades tend to be narrow, within a 20 to 30 gram range, and are often given identifying names such as 'jumbo crays' or 'cocktail crays'. Weight may be expressed as individual weight or number per kilogram. Typically, the smallest grade for redclaw is in the range of 30 to 50 grams, followed by 50 to 70 grams and so on. It is important that size grades match the customers' orders and that subsequent orders are consistent in both size and quality. A set of good electronic scales which can measure to an accuracy of one or two grams is essential in the grading facility.
- To improve the long term performance of the farm stock it is important to maintain superior animals, in terms of growth rate and appearance, as broodstock. As such animals are identified in the grading process, consideration should be given to this purpose and, where appropriate, these stock set aside for breeding.
- Redclaw that have just moulted or which are in the process of moulting, appear soft, limp and weak. These should not be packaged with live product. Markets are available for 'soft-shell' freshwater redclaw species overseas and could be developed in Australia. In the absence of a similar market for moulted redclaw, such individuals should be handled with care and kept in water until their shell hardens. This may be achieved in the holding system, or by stocking the redclaw back to a pond. Immediately after hardening they will appear shiny and very clean. Unfortunately, a proportion of these redclaw will die during the harvesting and grading processes as they are vulnerable to damage and under considerable physiological stress.

- Dirty or stained redclaw may be treated in some cases to clean them to an acceptable appearance (*see Specific treatments 6*).
- Colour is another factor which the grower should attempt to standardise. Variations in shell colour among redclaw may be maintained through the cooking process. For example, very dark animals will not display the desirable red shell colour when cooked. Although it is impossible for all redclaw to appear identical because factors including redclaw strain and pond environment will produce slight variations, inconsistency can be minimised by avoiding use of odd-coloured individuals as broodstock and discarding them during grading.
- It is important that some form of quality standard is adhered to by all suppliers. These standards may be informal, being set and regulated by the individual grower in consultation with his or her customers. Other growers who operate within marketing groups will have set standards which apply to all the group's suppliers.
- It may be undesirable to discard substandard redclaw, but the benefits both to individual farmers and to the redclaw industry of maintaining excellent quality standards cannot be ignored. It is in every grower's interest to ensure that poor quality product never has the chance to influence future reputation and sales. It is probable that markets for different quality grades can be developed. For example, undersized redclaw or those with stained shells could be processed into meat.
- Many customers are currently accepting consignments of mixed sex redclaw. Redclaw show a marked difference between the sexes of mature animals, with the females having smaller claws while the mature males' larger claws possess attractive red patches. This differentiation may result in some customers requiring redclaw to be graded by sex, especially if they are to be presented whole to the consumer.

4.3 Minimise stress to stock

- During grading for live sales, all precautions should be taken to minimise stress on the animals. Damage or stress may not appear to harm the animal immediately but mortality may result during or after transport.
- Grading areas should be cool and shaded.
- Redclaw should be kept out of water for the minimum period possible and clean, well-aerated water should always be used.

4.4 Handle redclaw with care

- Currently, on most redclaw farms, final grading is accomplished by hand, although labour and time can be saved by installing some form of size-graduated bars or screens in the flowtrap or holding tanks. Large producers of redclaw in

the United States have developed grading machines. Some of Australia's larger producers may adopt this technology as production volumes increase.

- Holding or moving large quantities of redclaw within crates or nets will probably cause some damage or crushing to animals on the bottom. Damage may not be obvious immediately. They should be carried and handled in small quantities, generally less than 8 kg per hand-held container.
- Redclaw should always be handled with care: placed and never thrown. Poor handling can result in internal damage, stress and subsequent mortality.
- Redclaw are capable of giving a painful bite with their large claws. While gloves may reduce the incidence of injury they may make movement awkward and slow down sorting. In order to avoid injury, correct handling methods should be applied (see Figure 6). As the handler becomes more confident and faster in his or her movements, such injuries become less frequent. In the event of a bite, the animal should be lowered so that its legs touch either the surface of the grading table or water. Most often it will then let go voluntarily. Handlers should avoid tugging the redclaw off a finger as this may result in damage to the crayfish, primarily loss of the claw.
- A grading table with dimensions of around 2.5 m x 1.5 m at waist height allows several sorters to work efficiently without causing undue back-strain. Aluminium or similar non-corrosive material allows the grading table to be regularly cleaned to prevent bacterial build up. The table should have a raised edge or lip to prevent redclaw from falling or climbing off the edge and a slight slope with a drain to remove water (see Figure 6).

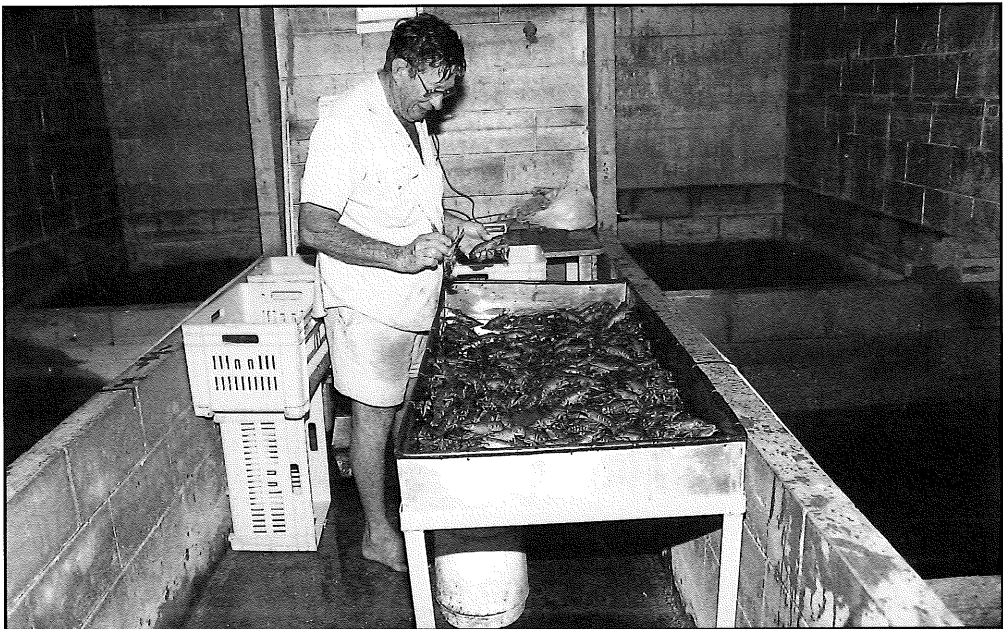


Figure 6. An aluminium sorting table facilitates quick and efficient sorting of product.

4.5 Minimise handling

- Redclaw being graded may be placed into plastic mesh containers with secure lids which allow water to circulate around and through them. It is preferable that these be shallow and wide, rather than deep, to avoid crushing the crayfish. Prawn trays (610 mm x 360 mm x 100 mm deep) are often used for this purpose (see Figure 7). Graded redclaw can be held within holding tanks in these trays for short periods prior to packing, without having to be re-handled.
- If holding period is longer than 24 hours, graded redclaw should be placed loose into tanks, or larger tanks can be divided by mesh screens to separate weight classes.

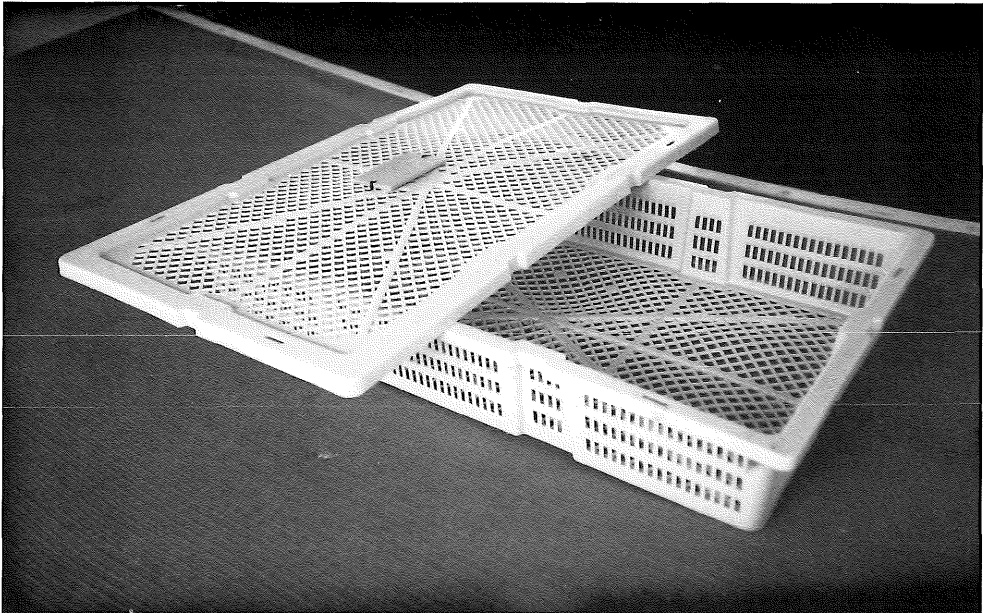


Figure 7. These plastic prawn trays are ideal for holding sorted product in water prior to packing for market.

4.6 Keep accurate records

- It is important to maintain accurate records of weights during grading and packing to ensure that no mistakes are made on a customer's order. Waterproof paper or notebooks are ideal for this purpose.
- Scales should be accurate to one to two grams and regularly checked and calibrated.

5 Purging

5.1 Why purge?

- Purging is the process of holding redclaw in a system which assists in the evacuation of all food and faecal matter from the digestive tract. Although the stomach of redclaw is not normally eaten, the hindgut which runs through the muscle of the tail carries faeces to the anus. This passage is often called 'the vein' in prawns and yabbies. Aesthetically, redclaw are far more pleasing if their gut is cleaned, as the presence of faeces is off-putting and they are often gritty.
- There may also be a risk of unpurged redclaw containing toxins (such as those produced by blue-green algae) which may at best produce an unpleasant taste and at worst create a serious public health risk (*see Harvesting 2*). Remember that a dissatisfied customer will not purchase product again and will almost certainly discourage other consumers.
- Waste products of redclaw metabolic activity need to be excreted via the gills, faeces and through the kidney-like antennal gland which is located in the redclaw head region near the mouth. These waste products may cause poor-tasting flesh and increased physical stress on the redclaw, but are largely eliminated through purging in clean water in the absence of food.
- Purging has the additional benefit of allowing the shell of the crayfish to be cleaned of external materials such as mud, algae and shell parasites, including flat worms. Some problems such as epistylis or 'hairy crayfish' are more resistant and require specific treatments (*see Specific treatments 6*).
- Purging also ensures that the water held in the gill chamber when redclaw are held out of water, has a low bacterial abundance. When a redclaw is removed from water it will tightly close the margin of the carapace which covers the gills in order to maintain a humid atmosphere for the continued uptake of oxygen by the gills. If the water contained within this chamber has a high organic load, such as exists in pond water, bacteria may multiply on the gill surface leading to mortality. Flowtrapping helps to prevent this because the gills are flushed with clean water during the harvesting process. If flow trapping is not employed, redclaw should be placed in clean water as soon as possible after harvest.

5.2 Purging period

- Optimal purging will be achieved within 24 to 72 hours. If redclaw are held for too long, stress and subsequent mortality may increase (*see Holding redclaw in tanks 3*).

5.3 Temperature

- The temperature of purging water should be cool, ideally between 15 and 20°C. By purging at low temperatures, the redclaw are less stressed, bacteria build-up is limited, the toxic effect of ammonia is reduced and there is less shock if redclaw are further chilled for packing (*see Pre-chilling live product 8*).
- It is easier to maintain cool temperatures in a recirculating system than in a flow-through system where new water is being constantly added. Water temperature may be lowered either through lowering air temperature in the room where the recirculation system is housed by air conditioning, or by cooling the water by means of a refrigeration unit.

5.4 System design

- It is essential that purging occur in specially designed purging systems, and not in ponds. One of two methods may be used: submerged purging or spray purging, each with its own design specifications. Consideration should be given to treatments that may be applied during purging, as this may have a bearing on the system design (*see Specific treatments 6*).

5.5 Submerged purging

This method involves holding the redclaw submerged in a flow-through or recirculating tank containing a substantial volume of clean, well-aerated water (*see Maintain water quality and cleanliness 3.4*).

5.5.1 System specifications

- A flow rate through the purging system sufficient to replace the volume of the system once every hour is necessary when very high densities of redclaw are being maintained.
- It is critical that tanks are checked frequently and dead redclaw removed. Dead animals may cause water quality to deteriorate rapidly, they may be a source of bacterial growth, and they may also be eaten by the remaining stock affecting purging efficiency.
- The tank should be designed to allow faeces to be removed daily either by siphoning or by draining. A sloping tank floor with a drain at the lower end can facilitate this. The tank system must be designed to ensure that water is well circulated and that all areas of water are well aerated.
- It is important to hold the redclaw on a false floor of mesh installed above the tank floor, or in perforated containers such as prawn trays. This allows the faeces to fall through the mesh where they cannot be reached and re-ingested by the redclaw.

- The false floor screens and tank itself should be kept clean and regular scrubbing of tanks between shipments should be standard practice.
- Regular monitoring of water quality must be undertaken and optimal water quality maintained. It is critical to keep levels of ammonia and nitrite below 0.1mg/L. Dissolved oxygen should always be maintained at 100% saturation when high densities are being held. The pH of the water will also affect the toxicity of any ammonia in the system, with the ammonia becoming significantly more toxic as pH and temperature increase. To minimise any risk, pH should be maintained between 7.0 and 8.0. If the system is holding a large volume of redclaw, a partial water exchange of 10 to 20 percent per day is good practice. It is important that the farmer is familiar with testing methods and has a good understanding of water quality, especially when recirculating systems are used (*see further reading 10 and Appendix 1*).

5.5.2 Purging period

- A period of 24 hours should be sufficient for effective purging, although redclaw may be purged for 2 to 3 days if a longer holding time is required prior to sale. Periods exceeding 24 hours in holding or purging tanks may cause increased mortality during or after live transport.

5.6 Drip or spray purging

- In this method the redclaw are held in a series of stacked, perforated trays through which cool, clean water is sprayed in a fine mist. This method is advantageous as it uses a minimum of water and allows retrieval of redclaw which can be pre-weighed and graded. It also ensures that the redclaw are constantly exposed to fresh, clean water.

5.6.1 System specifications

- The air temperature in the spraying room should be cooled by air conditioning, which keeps the fine mist spray of water at an equivalent temperature.
- All trays should be checked for mortalities daily.
- Just as in a submerged system, water quality should be monitored daily, especially if the system involves recirculation of the water.
- All trays should be cleaned well as each container of redclaw is removed. Cleaning all equipment with diluted chlorine and then rinsing provides effective sterilisation. Drying in strong sunlight is also effective.

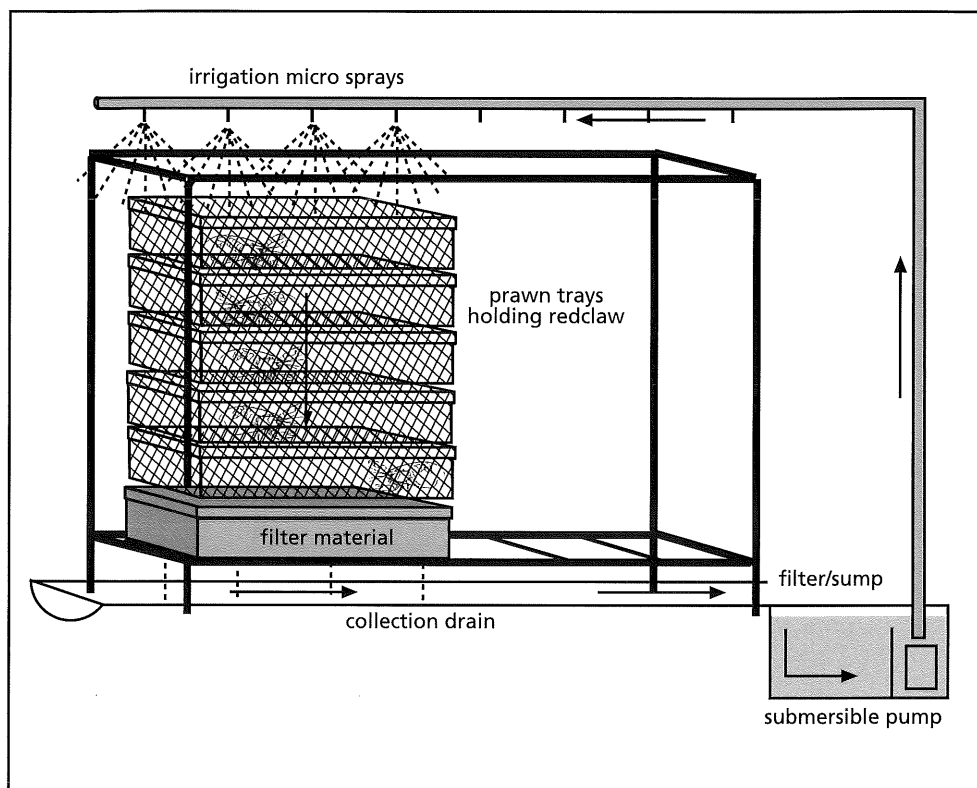


Figure 8. Diagram of a recirculating spray purge system. (adapted from Mosig, 1995, p128)

5.6.2 Purging period

- The drip or spray system has been applied most commonly for yabbies, particularly in Western Australia. A purging period of 72 hours in the spray system has been recommended (Mosig, 1995; Anon. 1998), however, shorter purging periods are preferable for redclaw.

6 Specific treatments

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6.1 Shell fouling

- Shell fouling is caused by the growth of either plant or animal material on the shell of the redclaw. It can vary in severity from mild, making the product slightly less attractive, to severe, rendering it totally unsaleable. Heavy infestations of parasites may also affect the health of the redclaw if they colonise the gill surface and hinder oxygen transfer. This may then have a severe impact on live transport.
- Sampling of stock prior to harvest will indicate whether shell fouling is a problem. During severe fouling, harvesting should be postponed until the problem has been resolved. All shell fouling problems can be attributed to high organic load in the pond water. Fertilisation rates and feed rates should be adjusted in relation to shell condition (gauged from regular sampling). A partial water exchange of the pond will improve the situation where shell fouling has occurred.

6.1.1 Scrubbing

- The eggs of some parasites may be firmly attached to the shell and may not respond to dips or baths. Affected animals can be scrubbed by hand with a brush (a toothbrush works well) but this is a labour intensive and inefficient practice for larger operations. Scrubbing also causes stress and sometimes physical damage to the redclaw.

6.1.2 Water spray

- Some shell fouling organisms may be effectively removed by subjecting the redclaw directly to spraying water. The redclaw are not submerged, and the physical action of the spray and of the redclaw crawling over each other can treat minor problems.

6.1.3 Salt bathing

- Treating redclaw in a salt bath of 10 parts per thousand (ppt) (e.g. 1 kg of butchers' salt to every 100 litres of fresh water) for 3 to 6 hours is an effective treatment for removing some external parasites including the orange temnocephalid flat worms and *Epistylis*, which causes 'furry' looking redclaw. Salt bathing, however, does place some physiological stress on the redclaw which may lead to increased mortality during or after live transport. This may be reduced by submerging the redclaw in fresh, clean water for one hour following the salt bath.

- Salt bathing may also assist in reducing the bacterial load which otherwise builds up in the gill chamber after redclaw are removed from water. Research indicates however, that many potentially harmful species of bacteria can thrive in quite high salinities. It is therefore recommended that attention be focussed on cleanliness of the system to minimise bacteria, rather than on saline treatments.
- It is important to note that when freshwater species such as redclaw are in higher salinities, they are placed under increased respiratory stress and aeration should therefore be maximised.
- As the salt bath is static, density should be no more than 100 g of redclaw to 1 litre of water. In addition, redclaw should be purged prior to salt bathing to minimise deterioration of water quality.

6.2 Shell staining

- Staining of the shell is a relatively common problem which at its worst causes the redclaw to appear very black and dirty. This can be seen clearly on the normally pearly-white under side of the tail of affected redclaw. Staining can be caused by the deposition of metal compounds including manganese and iron in ponds which are either constructed in affected soils or use a water source particularly high in these elements. Ponds which are carrying a very high organic load also may suffer from this problem (*see Shell fouling 6.1*).
- Normal purging, salt bathing and even scrubbing are ineffective in removing the stain. However, dipping in molasses can be effective. The mild organic acids in molasses have been found to dissolve the stain. There is no prescribed concentration of molasses based on research and there is room for further grower experimentation to suit individual problems. However, as a rule of thumb the following procedure has been effective.
- An equal quantity of molasses to the quantity of redclaw to be treated is poured into a plastic tub, for example 20 litres of molasses for 20 kg of redclaw. A volume of water equivalent to half the volume of molasses (10 litres) is added to the tub. The 20 kg of redclaw are treated in this bath for a period not exceeding 20 minutes and then placed into a tank of clean, well-aerated water for several hours prior to processing or packaging.
- Other diluted acids (hydrochloric or acetic) may have potential to treat shell staining of crayfish although these have not been investigated. The advantage of molasses is that it is organic and appropriate to a 'clean and green' image, and safe in terms of staff and storage concerns.

6.3 Flavour enhancement

- While some consumers have suggested that the flavour of freshwater crustaceans is excessively mild, this is not problematic in those markets, such as Europe, where freshwater crayfish are an established product. Familiarity with the

product will help to change this opinion. There is the potential however, to condition redclaw in saline water to satisfy any demand for a stronger-flavoured product. The saline water increases strength of flavour by facilitating the release of flavour-rich amino acids in the flesh, as a byproduct of the physiological process that helps balance the salinity of the redclaw's body fluids relative to the water in which it is immersed. It does not simply make the flesh more salty.

6.3.1 Salt bathing

- Australian taste tests showed that the flavour of redclaw which were held in 3% salt for 48 hours was significantly better than animals remaining in fresh water (Jones, 1990).

6.3.2 Transport following salt treatment

- When salt treatment is followed by transportation, significant mortality may occur due to the compounding of stress.
- Redclaw held in salinities of 2.5% for 24 hours suffer a weight loss of around 3% due to moisture loss (Jones, 1990). Such weight loss will increase with length of treatment, time and salinity.
- If redclaw are to be salt-treated to improve taste, it is preferable that this be performed by the buyer after live transport. Alternatively, the product should be cooked or frozen following the treatment.

7 Transport of live redclaw

The method and materials used for packaging redclaw for live delivery to market, and the mode of transportation used will depend upon the distance to be travelled and the time taken to reach the destination. To a large extent, the price received for the product will dictate the viability of live transport, as the most effective packing materials to reduce mortality can be expensive. Requirements for transport within Australia can be as demanding as those for export. Packaging and transport concerns become more critical as time in transit increases, and protocols for local, interstate and export markets therefore vary. Nevertheless, there are standard principles for handling and packaging redclaw that should always be followed regardless of destination.

7.1 Minimise transport time

- It is preferable that redclaw reach their destination within 48 hours of packaging. Transport exceeding 48 hours is likely to result in increased mortality and poor recovery upon arrival. Owing to the large distances between Australian centres, air transport is often necessary to access markets within a reasonable time.

7.2 Keep cool

- By keeping redclaw cool, metabolic rate is slowed down which reduces stress, movement and oxygen consumption during transport.
- Packing facilities should be air-conditioned and in close proximity to purging tanks. Redclaw should never be subjected to elevated temperatures (i.e. greater than 25°C) during the post-harvest period.
- For journeys greater than 1 hour it will be necessary to include a frozen gel pack or equivalent in the box. Ice packs should be insulated to avoid direct contact with redclaw and placed at the top of boxes because cold air falls.
- Pre-chilling product at 10°C for ten minutes prior to packing is recommended for journeys exceeding 12 hours (*see Pre-chilling live product 8*).
- It is recommended that water temperatures in purging tanks be maintained below 20°C to avoid temperature shock during pre-chilling (*see Purging 5*).
- Although redclaw should be kept cool, temperatures below 10°C may cause mortality if allowed to persist for more than a few minutes.
- Oxygen saturation of air within the box is unlikely to drop significantly within 48 hours. Any risk of oxygen depletion is reduced further by pre-chilling redclaw which will lower their metabolic rate and therefore the demand for oxygen (*see Pre-chilling live product 8*).

7.3 Keep moist

- Never transport or hold redclaw in un-aerated water, or allow water to exceed 1 cm depth in the transport box. Once redclaw have used all available oxygen within water they will asphyxiate and die. Redclaw should be transported in a moist environment, but out of water.
Note: Juveniles however, are an exception and are often successfully transported in oxygenated bags.
- If redclaw to be packed are too dry, they may be sprayed with water.
- The packing box should be equipped with moistened foam or equivalent to maintain humidity.

7.4 Discard sub-standard animals

- Some redclaw appear less vigorous and may appear limp or show evidence of swelling or separation of the membrane which joins the head and tail. These redclaw are preparing to moult, and the soft-shelled post-moult redclaw or any other weak individuals should never be packed for live transport. They are unlikely to survive the additional stress of transportation. These redclaw can be returned to a tank for another two or three days to complete their moult and recover. Of course, the stress they have been subjected to already during the harvesting, grading and purging processes may have already taken their toll and a certain proportion may not recover.

7.5 Maintain accuracy

- Packing rooms should be kept clean and uncluttered, accurate scales should be used for weighing and detailed records kept.
- Weighing scales should be tested regularly for accuracy.

7.6 Compensate for weight loss

- Redclaw will lose weight during exposure to air: the longer the journey, the greater will be the weight loss experienced. Weight loss in marron transported and packed in a comparable way to redclaw was estimated to be 3.3% at 12 hours and 3.9% at 24 hours, increasing to 4.3% after a further 24 hours. An additional 5% of product weight should be provided for live transport to distant markets to compensate for this loss. An additional 2 to 3% may be sufficient to cover weight loss over shorter periods.
- Weight loss can be minimised by allowing water to drain from redclaw for approximately five minutes prior to packing, and by ensuring that any packing media such as wood shavings or coconut fibre are well moistened (but not dripping wet) to maintain humidity in the boxes.

- Immobilisation by pre-chilling product and maintaining cool temperatures in the box will lower activity and limit evaporation losses, helping to minimise subsequent weight loss.
- If redclaw are re-immersed in water at their destination they will regain much of their original weight.

7.7 Handle with care

- Redclaw should always be handled with care and should be packed right way up, by hand: never thrown or poured into a box.
- Never drop or throw boxes containing redclaw.

7.8 Appropriate packaging

- Cost of packaging materials and price received for redclaw will dictate commercial viability of live transport. A small increase in both the cost of packaging and the care taken with transport methods may result in significant decreases in post-transport mortality. Clearly, a buyer expecting live product who consistently receives a proportion of dead redclaw, will not be satisfied. Appropriate packaging may make the difference between an on-going market and a short-term one.
- There are minimum packaging requirements which apply to any journey length. Beyond these requirements there will be increasingly demanding standards for longer transport periods.

7.9 Avoid crushing

- As there is a risk that crushing may damage redclaw packed on the bottom of the box, it is recommended that no more than 5 kg of product be packed in one layer. For a standard 10 kg styrofoam box, a false floor can be used to divide the contents. This should be perforated to allow cool air to circulate throughout the box. Some manufacturers produce boxes suitable for seafood which come equipped with such dividers. Alternatively, several small boxes may be used which are then held within a larger outer box (Figure 9).

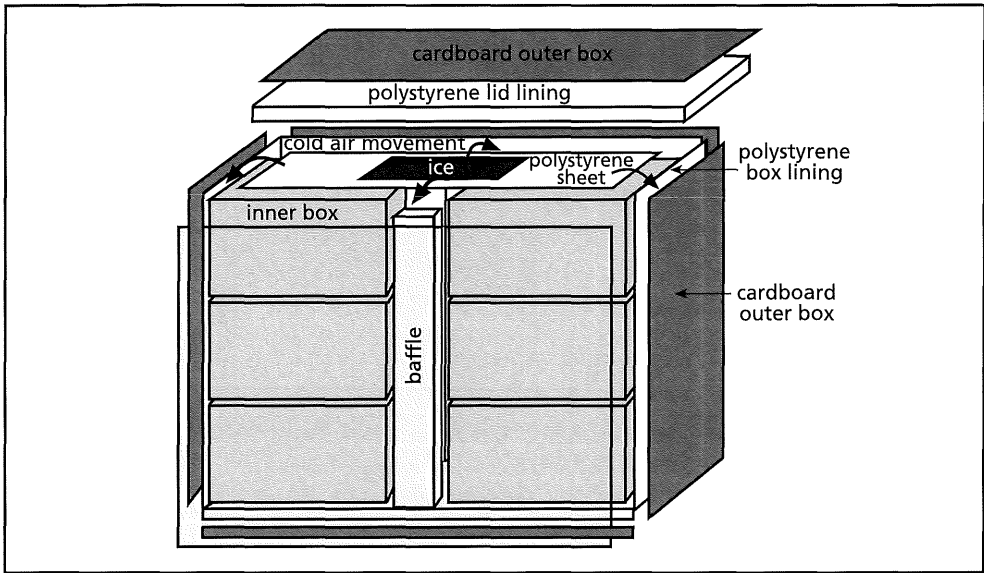


Figure 9. Diagram of packing system used for export of live Kuruma prawns and also suitable for redclaw transport.

7.10 Minimise vibration

- Avoid road transport over periods greater than one hour, unless packaging includes cushioning material such as wood shavings or wood wool. Wood products used for packing should be chemical free. Wood shavings are considered the most efficient.
- Always pack boxes fully, using padding material to fill spaces. This will prevent jolting and movement of redclaw.
- Never drop or throw boxes.
- Some shipments of redclaw have been sent in the cargo sections of buses, but unacceptably high levels of mortality have regularly occurred. This is probably a result of excessive temperature and/or vibration. Transport by bus for extended periods is not recommended.

7.11 Care at destination

- Buyers of live redclaw should be provided with written instructions regarding care of the product (*see Appendix 2*). Never assume that the buyer knows how to handle and maintain live redclaw.
- Because redclaw is a tropical species, it will not survive storage in a coolroom or coldroom at less than 10°C.
- Follow up on new orders to ensure redclaw are received and remain in good condition.

7.12 Requirements for local, domestic and international transport of live product

	Local	Domestic	International
Transport time and mode 7.1	Road up to one hour.	No more than 48 hours. Air or some form of refrigerated road transport. (Note 1)	No more than 48 hours. Air freight is the only viable method of transport. (Note 5)
Keep cool 7.2	Move in the morning. Up to 10 kg without prior chilling in styrofoam box with 500 mL to 1 litre ice pack. Keep boxes shaded.	1 litre frozen gel pack will do to cool redclaw for up to 48 hours. (Note 2)	As for domestic
Pre-chill product 7.2	Not necessary	Chill for journeys of 24 hours or longer. (Note 3)	As for domestic
Keep moist 7.3	Should be moist enough from purging.	Do not submerge the redclaw. Spray 10°C water over each layer during packaging. If not using wood shavings or similar, a thin layer of wet foam on the floor of the box is useful.	As for domestic
Minimise vibration 7.10	Pack firmly. Do not drop or throw boxes. May need to add cushioning.	Pack in layers with dividers and or padding. Boxes should have no empty space. Check airline restrictions for packaging. (Note 4)	As for domestic. Use approved packaging. (Note 6)
Compensate for weight loss	Pack extra 2–3% bodyweight.	Pack extra 5% bodyweight.	Pack extra 5% bodyweight.
Comply with regulations		Check interstate rules	AQIS can assist with information regarding requirements for various countries.

Note 1.

- There is potential for road transport over shorter distances; refrigerated trucks which carry fruit often operate at temperatures suitable for transporting redclaw. For example, bananas are transported to Brisbane from Cairns at between 12 and 15°C. This temperature range is suitable for redclaw. However, redclaw will perish at prolonged temperatures below 10°C. Additional care must be taken when packing animals for road transport to compensate for additional vibration and the risk of delays.
- Air freight will in most cases be the method of choice. Increased survival should compensate for additional freight expense.

Note 2.

- For longer journeys, a frozen gel pack is essential. It is recommended that a food grade gel freezer pack or ice brick is used as these are acceptable to airlines, remain cool for longer, look more professional than a newspaper-wrapped milk bottle and take up less space in the box. A 1 litre chill pack will usually suffice for a 48 hour journey if redclaw are cool when packed.
- Ice packs should be insulated to avoid direct contact with redclaw and placed at the top of boxes. Cold air falls.

Note 3.

- Chilling slows the metabolic processes of the redclaw, decreasing oxygen demand and movement and therefore risk of damage. It is very difficult to efficiently pack lively redclaw (*see Pre-chilling 8*).
- Chilling from room (ambient) temperature (>20°C) should be done in 5°C steps to minimise stress (*see Pre-chilling 8*).

Note 4.

- It is recommended that chilled redclaw be packed in layers with some form of divider or padding to minimise crushing. Clean pine shavings, which are recommended for packing redclaw for live export, are of great benefit in cushioning individuals against vibration, movement and crushing for domestic travel.
Note that wood products used for packing should be chemical free.
- Boxes should never contain empty space as this allows the redclaw to be jolted during movement. Padding should be used to fill any empty spaces in the box. This padding may consist of onion bags or similar mesh, pine wood shavings or wood wool.
- Packing materials occupy space and will restrict the weight of product that can be placed in a box. Wood shavings are considered the most efficient.

Note 5.

- Although redclaw destined for export markets may attract high prices, more risks are faced in transit and extra care in the packing process is therefore critical. While securing an export market is a desirable goal, careful consideration must be given to the cost–benefit ratio. The additional difficulties of transporting live product offshore must be compensated for by value.
- Air freight is the only viable method of exporting live aquatic animals. Farms that are situated close to international airports have a clear advantage for export.
- Arranging air freight can be a complicated business. Use of a freight forwarding agent who specialises in perishable products can be a distinct advantage.

Note 6.

- Fibreboard boxes and styrofoam fish boxes (with or without fibreboard outer packaging) are commonly used and are available in different sizes, however these must comply with airline standards. Whichever box is chosen it must be acceptable to the importer in terms of their own preference and any laws regarding recycling or waste control.
- Kuruma prawn packing systems (Figure 9) have been successfully used for redclaw. These generally consist of 6 kg small, inner cardboard boxes which each hold between 1 and 1.5 kg of product in layers separated and surrounded with pine shavings. These small boxes are packed into a larger, outer cardboard box lined with sheets of styrofoam. Two baffles maintain a space for air circulation around the boxes and a frozen gel pack is positioned on top. These boxes present live redclaw extremely well in convenient weight portions, however comparable mortalities still occur and they are more expensive than the standard styrofoam box.
- No air holes are required in the boxes and in fact, this practice may be unacceptable to some airlines. It is far more important that cool temperatures are maintained, and if this is the case, low oxygen levels will not be a problem. Furthermore, making air holes reduces the insulating properties of the box.
- Airlines prefer boxes to be sealed with printed tape so that it is easy to recognise which way up they should be placed.
- Oxygen generating tablets or other devices are often used for transport to international destinations. There is no evidence that their use is necessary, when all other transport specifications are adhered to.

8 Pre-chilling live product

Chilling redclaw prior to packaging for live transport has several advantages which result in improved survival during transit. As redclaw are a cold-blooded animal, their body temperature reflects that of the surrounding environment, unlike warm-blooded animals which self-regulate body temperature. By exposing redclaw to a low temperature bath, the body temperature is reduced, metabolic processes such as respiration are slowed down, and an immobilised, sleep-like state is achieved. Redclaw in this state are less able to injure themselves or each other and suffer less stress and damage while out of water. Most importantly, they are much easier to pack; it is very difficult to efficiently pack lively redclaw!

8.1.1 Chilling

- Redclaw appear to enter the torpid or sleep state at between 10 and 13°C. At this temperature, redclaw typically lie on their sides and display only weak waving of walking legs.

8.1.2 Chill gradually

- It is preferable to reduce temperature gradually to 10°C rather than in one sudden drop. Chilling from room (ambient) temperature (>20°C) should be done in 5°C steps to minimise stress (*see Pre-chilling 8*).
- Chilling redclaw by placing them firstly in an ice bath at 15°C for 10 minutes followed by immersion in a 10°C ice bath for a further 10 minutes is a simple method in the absence of more sophisticated chilling systems.
- The chilling process is aided by maintaining purging tank temperatures at between 15 and 20°C and packing crayfish in an air-conditioned room. Once removed from a 10°C bath, redclaw will warm up rapidly, negating the chilling process if exposed to warm air temperature. Consequently, packing should be completed soon after removal from the chilling bath.

8.1.3 Maintain low temperature

- A suitable ice bath can be created in a small tub of water to which ice is added until the desired temperature is achieved. For larger operators, a temperature controlled, refrigeration unit will be necessary. Water temperatures will remain constant for longer if the bath is situated in either an air-conditioned room or a cold room with an air temperature between 10 and 15°C.
- Check the chilling bath temperature frequently and adjust as necessary to maintain the desired range.

8.1.4 Maintain excellent water quality

- A chilling bath should always be well aerated.
- The water in the chilling bath should be discarded and replaced regularly through the packing of each shipment. As a rule of thumb, replace water for every 300 kg of product, or sooner if water quality is compromised.

8.1.5 Minimise stress

- For convenience and efficiency, the required weight of redclaw for a shipment can be pre-weighed and set aside in prawn trays or equivalent for purging. These pre-weighed batches can then be easily moved through the chilling process prior to packing, without having to handle individuals.
- Do not leave crayfish in chilling water for too long or allow temperature to drop below 9 to 10°C.
- Handle redclaw with care at all times.

9 Processing redclaw

9.1 Benefits of processing

- Processing redclaw by chilling or freezing uncooked product, or by cooking and chilling requires specialised and approved facilities. Despite the additional effort and cost, there are distinct advantages over dealing with live product. Advantages of processed redclaw include:
 - Processed redclaw may be stockpiled to cover times of inadequate supply.
 - There are no risks of mortalities occurring during transport.
 - Quality can be assured upon arrival at destination.
 - Some countries do not accept the importation of live animals.
 - There is the potential to offer a diverse range of processed and value-added redclaw products.
 - There is the potential to develop uses for different grades of redclaw. For example, those with missing claws or dirty shells may be tailed or used in the production of redclaw meat products such as pâtés.
 - Retail outlets may prefer processed product to sell to their customers. For example, it is difficult to sell live product to supermarket customers.
 - Consumers are often uncomfortable with trying a new product which is live because they do not know how to handle, prepare or cook it.
 - Some customers prefer the convenience of processed product as it is easier to store for longer periods, without specialised knowledge and equipment.
 - Ongoing mortality of live product once received by the customer is likely.
 - Live redclaw can be transported only to destinations which can be reached within 48 hours, without excessive risk of losses. Processed product can be sent further afield with less risk to the grower or seller, who usually must cover any losses during transit.
 - Transport costs for processed product can be reduced, as containerisation and road or boat transport are options not generally suitable for live product.

9.2 Killing redclaw for processing

9.2.1 Kill before cooking

- Redclaw should be killed before cooking. If they are cooked live they may throw their claws or legs.
- Boiling of live product is recognised as inhumane and may be legislated against.

9.2.2 Cold shock to kill

- The simplest method of killing is to subject redclaw to cold shock, either by placing into an ice slurry (equal parts of ice and water) or freezer at -18°C. Death will occur within minutes.

9.2.3 Avoid exposure to air

- If whole animals are being sold, redclaw should be transferred instantly between tank and ice slurry, and between ice slurry and cooker. If they are exposed to air, water will drain out of the gill chamber causing an unattractive lightened patch to appear on the shell covering the gills following cooking.

9.3 Preparing redclaw for cooking or freezing

- *Whole:* For product to be served whole, no prior preparation is necessary
- *Tails:* The head is simply broken away from the tail by hand using a half twist and pull. If tails are to be peeled, the membrane ridges on the underside of the tail can be broken by applying pressure with the thumbs. The tail meat can then be removed by breaking the shell apart. Alternatively, the membrane can be cut lengthwise with either a knife or scissors. With a meat recovery rate of around 25%, there is potential for viable sales of redclaw meat.
- *Halved:* Redclaw can be presented in the half shell, which allows the meat to be easily eaten without peeling the animal. A knife or cleaver is placed along the length of the upper side of the crayfish and pressure is applied downwards to halve the animal. Meat can be removed with a fork following cooking. Either the whole redclaw or just the tail can be halved this way. If the whole animal is being presented in this manner, some consumers like to use the hepatopancreas (often referred to as the 'mustard' or 'brains') which is located in the head region and is full of flavoursome oils, as a sauce.
- When halving redclaw the tail can be completely severed lengthwise or just cut through to the tail membrane and folded open to create a butterfly tail.
- Properly purged redclaw do not require de-veining.
- If desired, the tails of whole redclaw can be prevented from curling when cooking or freezing by tying the redclaw to a board or 'tummy to tummy' with another redclaw using rubber bands or similar.

9.4 How to cook redclaw

9.4.1 Process

- Redclaw may be boiled, steamed or microwaved prior to sale. Method of cooking has limited influence on the flavour of redclaw, but boiling results in the best percentage of flesh recovery (Jones 1990). Kill redclaw before cooking (*see Killing redclaw for processing 9.2*).
- Transfer immediately to cooking water and do not allow crayfish to drain.
- After cooking redclaw, immersion in sodium metabisulphate (or equivalent) will help to prevent blackening resulting from enzymatic activity.

9.4.2 Cooking time

- Any pot that is large enough to hold the desired quantity of product and water without over-filling is adequate for small volumes. For larger operations, gas prawn cookers are often used.
- Sufficient cooking water should be used to prevent its temperature falling too much upon addition of the chilled redclaw. As a rule of thumb there should be four times the volume of water to the volume of crayfish.
- Place the redclaw which have just been killed into rapidly boiling water. Bring water back to the boil and then simmer, covered, until cooked. When cooked, redclaw flesh will have just turned uniformly opaque and be just firm. The shell will be orange or red. In boiling water a 60 to 85 g whole redclaw should take approximately seven minutes with the water constantly boiling.
- The flesh of overcooked crustaceans will become tough and rubbery.

9.4.3 Chill or freeze immediately

- Drain immediately when cooked and cover redclaw immediately with ice or place in ice slurry or freezer for five minutes. Quick chilling prevents overcooking and arrests bacterial and enzymatic breakdown.
- Use of a sodium metabisulphate (or equivalent) bath will help to prevent blackening.

9.4.4 Use of salt

- *Adding salt to cooking water:* Salt may be added to the cooking water at a concentration of 3% to alter the taste if desired. However, formal taste evaluation showed only very slight preference for animals cooked in brine solutions, with 30% of participants unable to tell the difference (Jones 1990, p86).
- *Adding salt to post-cooking ice slurry:* After cooking, redclaw can be transferred immediately to a fresh ice slurry containing 3% salt, which is taken up by the

flesh. Never use the same ice slurry in which the animals are killed! Some producers have experimented with adding other flavours to the cooking water or ice slurry.

9.5 Further value-adding

9.5.1 Freezing redclaw

- For freezing, redclaw should be snap frozen at -18°C or lower. A domestic deep freezer is inadequate for the job. For smaller producers it may be more practical to out-source the freezing process to a wholesaler rather than purchase the necessary equipment.
- Redclaw that are frozen dry may throw their claws, and are more susceptible to damage. It is advisable to freeze them in an ice glaze.
- Redclaw may need to be frozen in quantities that are convenient for the customer to use without wastage. For example 1 kg blocks of tail meat or whole animals may be the preferred portion size rather than frozen blocks of 10 kg.
- Results of sensory evaluations showed that there was very little deterioration of frozen redclaw over 6 months at -20°C . Note that frozen, cooked redclaw had a less acceptable flavour when compared with frozen, green redclaw which were cooked after thawing (Jones 1990, p 96).

9.5.2 Other value-adding

- There is scope for further methods of preparing and cooking redclaw which will help to widen product appeal and meet niche market demands. These may involve marinating, pickling, smoking, preparing ready-to-cook meals or pâtés.



Figure 10. Quality redclaw provide great scope for attractive culinary presentation.

10 Further information

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Appendix 1. Relative merits of flow-through and recirculating systems for holding redclaw in tanks

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Crayfish excrete ammonia as a waste product. This subsequently breaks down into nitrite and then nitrate. Both ammonia and nitrite are extremely toxic to redclaw. Biological filtration is used in recirculating systems to convert ammonia into less toxic compounds. In a biological filter, beneficial bacteria form colonies on suitable substrates such as gravel, coarse sand, fibrous matting, or other surfaces specifically manufactured for this purpose. As water passes from the holding tanks through the biological filter, the bacteria convert the wastes into less toxic forms before the water returns to the tank. Producers should seek specific information and/or advice from an expert source before setting up biological filtration systems. (*see Further information 10*).

Advantages of flow-through systems	Disadvantages of flow-through systems
Water quality is assured if source water is of good quality.	Impractical on farms where water is not cheap, abundant and of consistent quality.
Densities of redclaw within the tanks can fluctuate.	Water temperatures will fluctuate.
Simple and easy to manage	Less control possible over the tank environment
Advantages of recirculating systems	Disadvantages of recirculating systems
Tank conditions, including temperature, can be consistent.	Requires a more in-depth knowledge of water quality and treatment, and more intensive management.
Uses minimal amounts of water.	Biological filters, which treat redclaw wastes through the action of beneficial bacteria, cannot cope well with sudden large increases in redclaw numbers.
System is self-contained and not at risk from contamination or interruptions to supply.	Requires more intensive management, especially when the system is new.

Appendix 2. Requirements and storage times for holding live and processed redclaw

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The following information assumes that live and chilled redclaw were received within 3 days of harvest, that frozen product was snap frozen no longer than 2 months prior to delivery, and that redclaw were received in excellent condition and stored appropriately. It is to be used as a guide only.

	Live	
	In water	Out of water
Maximum time	Indefinite in good quality water for some individuals, but mortality rates of 10–20% are often experienced during 3 day period following re-immersion (most commonly on day 2).	3 days upon receipt for most individuals, however continuing steady mortality may be experienced.
Temperature	15–25°C	15–25°C, not in direct contact with ice. A cold room is not suitable.
Salinity	0–5 ppt	N/A
Humidity	N/A	Keep moist but not submerged. Spray with water frequently and cover with damp sack or similar material.
Holding Container	Tank with good filtration and aeration systems.	Styrofoam fish box or plastic tub. Original packing box may be suitable.
Other conditions	Keep dark, unless used in a display aquarium and avoid disturbances. Will not require feeding unless used for long term display.	Keep dark and avoid disturbances. Do not feed.

	Processed			
	Cooked Frozen	Cooked Chilled	Uncooked Frozen	Uncooked chilled
Maximum time	4–6 days	5–8 days	6 months	1–3 days
Temperature	-18°C**	1°C *	-18°C**	1°C *

* One hour out of storage, without ice, means a loss of one day's shelf life.

** Shelf life will be halved if the temperature is increased by 10°C.

