The Translocation of Freshwater Crayfish in Australia: Potential Impact, the Need for Control and Global Relevance

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ABSTRACT

Live freshwater crayfish from Australia, particularly the three commercially important species of Cherax tenuimanus, C. destructor and C. quadricarinatus, have been translocated extensively internationally and within Australia. Controls exist in Australia to prevent the importation of live freshwater crayfish, and to regulate their export, but consistency in attitudes and regulations across Australia is lacking for the control of their translocation between and within states. Given the potential problems of the translocation of freshwater crayfish (including those associated with the introduction of diseases, the competitive interactions between introduced and native species, habitat alterations, the loss of unique combinations of characteristics by hybridisation, and the loss of unique combinations of epibiotic species), more controls are required. The current ban on imported crayfish must be maintained; new regulations for intra- and interstate translocations should be consistent across Australia. Education programmes and an increased level of funding for disease research are seen as essential. Such recommendations might be of value to other countries if acted upon before problems are identified.

INTRODUCTION

The translocation of freshwater organisms for the purposes of recreational or commercial fisheries, aquaculture, the aquarium or pet trade, biological control or any other commercial or recreational objective has been rampant...
worldwide and Australia has not been exempt from its effects. The number of freshwater fish species which have been introduced to Australia and which have established self-maintaining populations attests to these activities. Freshwater crayfish are one of the groups subjected to translocations.

So far Australia has rarely dealt with introductions of exotic species of freshwater crayfish and most such events have been detected in transit. However, the translocation of Australian native species of freshwater crayfish has been effectively unrestrained within states, between states and internationally, for substantial periods in the past.

In Europe the extermination of populations of native species as the result of the introduction of North American freshwater crayfish species infected with the 'crayfish plague' disease has resulted in a heightened awareness of the problems associated with translocations of freshwater organisms. The cause has been taken up by the International Association for Astacology whose resolution at their 7th International Symposium in Switzerland 1987, recommended '. . . that Governments find the means to stop the importation of living crayfish into their countries for any purpose . . . except for governmentally approved research, restockings or introductions' and that '. . . those Governments should be responsible for assuring that such living crayfish are parasite and disease free'. The current upsurge of interest (both worldwide and within Australia) in Australian freshwater crayfish, their recreational value and aquaculture potential, the concurrent movement of crayfish species within Australia and the recognition that Australia has a very diverse assemblage of freshwater crayfish species (of which some are already threatened), necessitate an urgent review of the translocation of freshwater decapods in Australia.

The aims of this review are to examine the perceived reasons that have led to translocations of crayfish, the translocations which have occurred so far, the potential problems of translocation from a conservation point of view, what regulations exist in Australia, and finally the management implications.

**WHY TRANSLOCATE CRAYFISH?**

The translocation of freshwater crayfish has been driven by either commercial or recreational incentives, in the main to stock farm dams, ponds, or other waterways with a freshwater species which will provide a food source or a source of revenue. Some of the main motives for the movement of live crayfish include:

(i) scientific interest/research and/or exploration of aquaculture potential;
(ii) provision of live animals for the restaurant trade;
(iii) provision of live animals for the aquarium trade;
(iv) full-scale aquaculture exploitation; and
(v) stocking of farm dams for recreational purposes, and harvesting for household consumption (this often occurs on a local scale).

For each of these five objectives, the translocation process includes the collection and storage, transportation and establishment of translocated stock. In addition, and most importantly from a disease control point of view, translocation events may result in subsequent release of stock into nearby waterways as a means of disposal, and such events may lead to non-endemic species establishing self-maintaining populations.

**KNOWN TRANSLOCATION EVENTS**

Many episodes of movement of live crayfish in Australia have been recorded but many more are likely to have occurred. Translocations may have been carried out by Aborigines. For some species the range and frequency of translocation has been increased by Europeans. This section will outline only general aspects of translocations and the resultant distributions of some species will be considered.

Populations of yabbies *Cherax destructor* Clark and *C. albidus* Clark have had their ranges in central Australia and southeastern South Australia, respectively, artificially extended in all Australian states and mainland territories, and the former species has been introduced to both Western Australia and Tasmania (Zeidler, 1982; Austin, 1985, 1986; Sokol, 1988; Horwitz, unpublished data), where it has been placed mainly into farm dams (see below). *C. destructor* has been air-freighted overseas, for instance to North America for breeding (Carstairs, 1975) and to France for the restaurant trade (Anon., 1975).

Marron *Cherax tenuimanus* Smith is endemic to the southwest of Western Australia and has been transported widely, extending its range in Western Australia (Morrissy, 1978), at least into South Australia, southern Queensland and throughout New South Wales (Austin, 1985; Villarreal & Hutchings, 1986; Morrissy, 1988; B. J. Mills, pers. comm.), where they are found in farm dams and aquaculture ponds. Marron have recently been discovered in a National Park on Kangaroo Island, off the southern coast of Australia, the result of an illegal importation (S. Clarke, pers. comm.). The species has been exported to New Zealand (McDowall, 1988), various European countries (i.e. Great Britain, Sweden, France and Belgium; Huner, 1987), and to various Asian, African and North American countries (Huner, 1987).
Cerax quadricarinatus von Martens (red claw or tropical blue crayfish) has a natural range which includes New Guinea, the Northern Territory and northern Queensland (Austin, 1986), but has been introduced into southern Queensland (Herbert, 1987) and New South Wales (P. O'Connor, pers. comm.) for the purposes of aquaculture. It has recently been exported overseas (Hutchings, 1988), and there is a proposal to introduce it into both the Kimberley (northeast) and southwest regions of Western Australia (see Morrissy, 1988).

The overseas export of the last two species has accelerated over the last few years, and both government authorities and private companies have sought exports on a worldwide basis (see, for instance, Hutchings (1988) and advertisements in the Austasia Aquaculture Magazine May/June, 1986).

Minor translocations have been undertaken by researchers. For example, in Tasmania translocations of the native species (such as Astacopsis spp., Engaeus spp., Geocharax sp. and Parastacoides spp.) have been undertaken by researchers and fisheries authorities for determination of aquaculture potential, taxonomy, reproductive biology, ecology, physiology, etc. Live exportation of Astacopsis gouldi Clark to North America was undertaken in the past, and requests are still being received by authorities, presumably for scientific interest and examination of aquaculture potential. Species native to the Australian mainland have been translocated for the same reasons, and such movements have included transportation across state borders and even overseas, usually with the consent (by permit) of fisheries authorities. For instance, recent experiments on the growth of C. destructor involved the transferal of breeding adults from three geographically widespread populations to laboratory facilities in South Australia (Geddes et al., 1988).

A programme to determine the feasibility of re-introducing Euastacus armatus (von Martens) to the lower parts of the Murray River (following its apparent demise in that area) has been initiated and involves taking brood stock from mainly the upper reaches of the Murray River, developing a captive breeding population and eventually having trial releases into the area (Geddes & Mitchell, 1987).

**SOME POTENTIAL PROBLEMS RESULTING FROM TRANSLOCATION**

Potential problems with, or resulting from, the translocation of freshwater crayfish include introduction of diseases, competitive interactions between introduced and native species, habitat alterations, loss of unique combinations of characteristics by hybridisation, and loss of unique combinations of epibiotic species. Some of these issues have been briefly commented on by Holdich (1987).
Introduction of diseases

In general the disease status of Australian freshwater crayfish is poorly known (Mills, 1983; Paynter, 1986) and the lack of knowledge is particularly acute for hatchery or pond-reared crayfish (Paynter, 1986; Herbert, 1987), a surprisingly neglectful situation given the rapid development of the crayfish aquaculture industry, and presumably the optimal conditions for disease outbreaks which intensive aquatic farming provides. Studies have begun recently to alleviate this shortfall of information (Owens & Evans, 1989).

The most serious disease known for freshwater crayfish so far appears to be the epizootic crayfish plague disease, associated with the fungus *Aphanomyces astaci*. The following account is summarised from Alderman & Polglase (1988) and for further details the reader is referred to this review and the articles cited in it. The fungus appears to be native to North America where endemic crayfish species are highly resistant to infection; however, European, Asiatic and Australasian species appear to have little or no resistance to infection (Unestam, 1975), and in Europe the disease 'crayfish plague' has had widespread and devastating effects on crayfish populations, resulting in the listing of two native species as threatened by Wells *et al.* (1983). Mortality appears to be the result of one of at least two processes; if large numbers of zoospores infect the crayfish, the host's defences are overwhelmed. If few zoospores are present, brown melanisations spread on the host's exoskeleton and along with necrosis of underlying musculature eventually result in a secondary bacterial infection.

The fungus has not been identified from Australian waterways and no diseased crayfish have been declared. The potential for this fungus to cause a disease which could not only eliminate already rare and/or threatened species, but also other species which are commercially or recreationally important in Australia, is reason enough for tight controls on the importation of exotic species of crayfish, contingency plans for an outbreak of disease, an investigation of the pathogenicity of associated species of *Aphanomyces* and efficient quarantine regulations for the importation of other potential vectors of the fungus (such as infected water, fish, etc.).

Other important fungi known to infect Australian species (such as *C. quadricarinatus*) include forms that are likely to affect the eggs or larvae of hatchery-reared freshwater crayfish, such as *Saprolegnia* sp., *Fusarium* sp. and other unidentified oomycetes (Herbert, unpublished data cited in Paynter, 1986; Herbert, 1987). Stripped eggs are particularly susceptible (Herbert, 1987). It has been shown that *Saprolegnia* spp. can cause significant problems to European crayfish under intensive farming conditions, where low dissolved oxygen and high suspended solid levels may result in high stress levels and predispose the crayfish to infection by opportunistic
saprophytes (Vey, 1977, 1981, cited in Alderman & Polglase, 1988). The result to the host of a *Fusarium* infection of a wound can be serious since its effect is to lock the exoskeleton into the tissues beneath (Alderman & Polglase, 1988).

The 'enigmatic' parasite *Psorospermium* sp. (whose taxonomic affinities are uncertain) has recently been observed on a parastacid (*C. quadricarinatus*) where it infected the gills, connective and neural tissue, and occasionally ovary membrane, cardiac and skeletal muscle (Herbert, 1987). While no deleterious effects or immune responses were observed for this parasite of this species (Herbert, 1987), European experience suggests that if the conditions associated with intensive farming are responsible for its proliferation then the implications for this industry of *Psorospermium* parasitism are severe (Alderman & Polglase, 1988).

Of the protozoans known to infect freshwater crayfish, the microsporidian *Thelohania* sp., the cause of 'thelohaniasis' or 'porcelain disease' appears to be the most important. Infected muscle tissue (striated or cardiac) becomes opaque and white and the animals show weak tail flick responses and appear sluggish (Mills, 1983; Herbert, 1987). Infected animals are unmarketable (Alderman & Polglase, 1988) and for this reason the disease is considered by some to represent the most serious threat to the aquaculture industry (Owens & Evans, 1989). Again the potential for very high levels of infection exists under both semi-intensive and intensive culture conditions (Alderman & Polglase, 1988); infection rates so far recorded for Australian species are 1–20% and 7.8% in wild populations of *Cherax destructor* and *C. quadricarinatus* respectively (Mills, 1983; Herbert, 1987; see also Carstairs, 1979). *Thelohania*-like spores have also been described from southwestern Western Australia where they infected a specimen of *Cherax quinquecarinatus* (Grey) (Owens & Evans, 1989).

Ectocommensal protozoans known to be harboured by a variety of Australian freshwater crayfish include the peritrich and loricate ciliates *Lagenophrys* spp., *Pyxicola* spp., *Vorticella* sp., *Zoethannum* sp., *Cothurnia* sp. and *Epistylis* sp. (Kane, 1964; Mills, 1983; Paynter, 1986; Villarreal & Hutchings, 1986; Herbert, 1987; Alderman & Polglase, 1988). They are found on the carapace or in the gills of their hosts and under normal conditions do not harm the host. However, heavy infestations, normally indicative of poor water quality, may block the respiratory surface of the host, leading to death by hypoxia, and decrease the market value of covered individuals (Paynter, 1986).

Other metazoan commensals of Australian crayfish include rotifers, nematodes, temnocephalid and rhabdocoel platyhelminthid worms, polychaete and oligochaete annelid worms and ostracods (see, for example, Kane, 1964; Hart & Hart, 1967; Hickman, 1967; Mills, 1983; Paynter, 1986;
The effects of these parasites on the well-being of the host are either negligible or unknown. There are also several 'diseases' described for crayfish, for which no pathogen or mitigating organisms have been described, such as the blistering of the tail fan of species in the genus *Cherax* (see Mills, 1983; Paynter, 1986; Herbert, 1987). The nature of these diseases will probably not be understood until further research is initiated; there is a considerable paucity of information concerning bacterial and viral infections in Australian crayfish.

Some of the more important diseases are recognised by authorities; for instance, notifiable diseases in South Australia include *Psorospermium*, *Thelohania*, *Vorticella*, and *Cothurnia*. Indeed, several states now require certificates confirming the disease-free status of translocated stock. The effectiveness of regulations which pertain to the disease status of crayfish are dependent on the ability of certifiers to identify diseases and the honesty of fish farmers and importers to declare movements of stock. They are also reliant upon the knowledge which has been gained by researchers and published works, present in the public domain. The current lack of knowledge about the disease status of Australian freshwater crayfish must be seen as a severe impediment to the ability of authorities to identify a potentially harmful disease and to curtail its spread.

Given the scale of translocations currently being undertaken in Australia, outbreaks of (until now) endemic diseases could easily spread throughout a state and between states and pose a serious threat to rare and otherwise threatened native species.

**Displacement of native species (competitive interactions) and habitat alteration**

There have been neither accounts of displacement of native freshwater species by introduced species, nor detailed accounts of habitat alterations caused by the introduction of species in Australia. However, experience with northern hemisphere crayfish suggest that both are distinctly feasible in Australia. For instance, the rusty crayfish of North America *Orconectes rusticus* (Girard) was introduced to the Wisconsin area, probably by anglers using it as live bait. The crayfish is now held largely responsible for the disappearance of dense aquatic plant growth and the decline in numbers of two other conspecifics, *O. propinquus* (Girard) and *O. virilis* (Hagen), in several lakes in the north of the state (Lodge *et al.*, 1985).

The potential exists for *Cherax destructor* or *C. albidus*, currently mostly restricted to farm dams in southwestern Western Australia, to become established in the natural waterways of the region (Austin, 1985), and threats to the habitat such as the creation of extensive burrow systems in the banks
and bottoms of water bodies, the destruction of aquatic vegetation, increases in turbidity of the water and displacement of native crayfish species are possible as a result (Mills & McCloud, 1983; Austin, 1985).

**Loss of unique combination of characteristics of conspecifics by hybridisation**

If escape of translocated stock occurs then there is the possibility that introduced individuals will interbreed with native individuals of the same species, and if either populations exhibited distinct characteristics (morphological, biochemical or otherwise), then the resulting offspring will essentially provide a blend of the characteristics of both parents. Given continued interbreeding, the unique characteristics may still be present in the population but in altered frequencies and eventually no one individual will wholly exhibit the unique characteristics of either strain. Indeed, it would be theoretically difficult to artificially re-establish that unique combination of characteristics which characterised either population prior to the introduction. Such events are liable to be most important in areas where only a single or isolated population persists, such as a mound spring.

There is an obvious parallel here with the concerns raised for the proposed effects on the diversity of wild salmon resulting from the escape of genetically distinct fish from fish farms in Norway and elsewhere (Sattaur, 1989).

The conservation of genetic resources is usually viewed from a utilitarian stance (Frankel & Soulé, 1981) where the alteration of such genetic frequencies may be seen at least as a loss to aquaculturalists and scientists. But this ignores the view that genetically distinct populations have a right to exist irrespective of the behaviour of humans.

**Loss of unique combination of ectocommensal (or otherwise parasitic or symbiotic) species**

As stated above, freshwater crayfish harbour a variety of symbiotic or parasitic organisms, including bacteria, fungi, protozoans and invertebrates. The conservation of crayfish therefore, also involves the conservation of habitat which is required by a variety of organisms. Some of these species show little or low host specificity and exhibit wide geographical ranges (for instance the fungus *Aphanomyces astaci*). Others, however, show both host specificity and restricted distributional ranges and it is for these that the concern should be high.

A translocation event has the potential to introduce not only the crayfish themselves but also their parasites and symbionts. Under certain circumstances it is distinctly feasible that hosts will swap parasites and
symbionts and the translocation may therefore result in a loss of the combination of flora and fauna associated with the native species. At the most such translocations could result in the replacement and elimination of natural parasites and symbionts by out-competition, predation or microhabitat alteration and may even heighten the susceptibility of the host to infection by a pathogen whose effect was decreased by naturally occurring symbionts. This is an area little explored in crayfish biology and one which warrants further information.

REGULATIONS GOVERNING CRAYFISH TRANSLOCATION

The importation into Australia of live exotic freshwater crayfish is strictly regulated by the Wildlife Protection (Regulation of Exports and Imports) Act, 1982 administered by the Australian National Parks and Wildlife Service (ANPWS) and is not legally permissible unless written approval is provided by both ANPWS and the respective state authorities. In all cases this effectively means that their importation is totally banned.

Exportation

In general the primary constraint regarding the translocation of crayfish in and from Australia are those regulations which govern the collection of individuals. These vary from state to state, within some states and are occasionally species-specific.

Given these preliminary constraints, the international export of live crayfish for the purposes of aquaculture is possible providing that

(i) An export permit is obtained from the ANPWS. (There is a slight complication here: *Cherax destructor*, *C. albidus*, *C. tenuimanus*, and *Euastacus armatus*, appear on Schedule 4 of the Wildlife Protection (Regulation of Exports and Imports) Act, 1982, a list of species for which export is not prohibited; *Cherax quadricarinatus* does not appear on this list and therefore requires specific consideration by ANPWS.)

(ii) A Customs Declaration has been made.

(iii) A Commonwealth Department of Primary Industries and Energy Export Approval is given.

(iv) The relevant state regulations governing the sale and export of freshwater crayfish have been satisfied. Usually, the exporters will be aquaculture companies or farmers who have already satisfied the requirements.
In Tasmania the collection of native freshwater species is only possible under permit, and since the Inland Fisheries Commission (the authority responsible) has a policy of not allowing the export of native crayfish, collection for the purposes of international export is not permitted. No regulations operate to control export overseas from South Australia, Western Australia, Queensland, New South Wales and Victoria, where the exportation is usually supported as a contribution to the improvement of Australia’s trade balance.

**Domestic translocations (within states, and importation and exportation between states)**

This section is best discussed by state since regulations vary considerably. In general, exportation from each state or territory is not regulated (with the exception of Tasmania), movement within the state or territory is not regulated (with the exception of Northern Territory), but the importations are strictly governed.

In Tasmania species in the genus *Cherax* are considered as noxious pests and transfers of such species into the island are therefore prohibited. The export of crayfish from Tasmania is also prohibited.

Western Australia has not placed any restrictions on the movement within, or export interstate, of live crayfish (P. Rogers, pers. comm.). But, in order to import freshwater crustaceans into Western Australia, from either overseas or interstate, a licence is required from the Fisheries Department and this may require the applicant to obtain a disease-free certification, and for the stock to undergo strict quarantine on arrival in Western Australia (Anon., 1988). The Fisheries Department has a general policy of disallowing the farming of exotic crayfish species within the southwest of Western Australia (P. Rogers, pers. comm.).

No regulations operate to restrict movement of freshwater crustaceans within, or from, South Australia. However, *C. quadricarinatus* is not permitted into South Australia, and *C. tenuimanus* can only be imported with a Ministerial Exemption and a certificate certifying that the shipment is free from notifiable diseases (see above).

Queensland has no regulations prohibiting the import of species from within Australia but strictly adheres to the regulation that only pond-reared stock may be moved within Queensland. Certification of disease-free status is not required. Exportation interstate is not regulated provided that the animals concerned are farm-bred. Similarly, in New South Wales, there are no regulations guarding the importation of species from within Australia provided that permission is sought to stock waters in the first instance (farm dams are exempted from this) and that suitable measures are undertaken to
prevent the escape of stock (P. O'Connor, pers. comm.). In New South Wales an attempt is made to ensure that exporters are aware of the receiving state’s regulations (P. O'Connor, pers. comm.).

In Northern Territory marron, and other non-native species, are prohibited imports; otherwise, movement of stock into Northern Territory from other states is occurring and authorities require disease-free certifications, and a permit is required to move stocks within the state (N. Sammy, pers. comm.). In Victoria marron are also prohibited, being considered a noxious fish, and applications for fish culture permits for red claw, whilst this species does not have the same legal status, have so far been refused (R. Fallu, pers. comm.); there are no attempts made to restrict the movement of crayfish within Victoria, nor from Victoria to other states (provided that fish culture permits are obtained).

In summary, there are elements of the current regulations in each state which will most likely lead to a lessening of the frequency and/or the effect of an unwelcome translocation of freshwater crayfish. However, there are clear differences between the states, for instance with requirements for an assessment of disease status of translocated stock, and this appears to reflect the dichotomy of approaches to regulations; where minimal controls are applied the industry is understood to regulate itself in a satisfactory manner, and where stricter regulations are in force the industry is perceived to be likely to have an element of irresponsible behaviour which might affect others.

**Management implications**

Some workers have recently called for fisheries authorities to judge the usefulness of translocation rather than entrepreneurial interests (see for example Morrissy, 1988); on the other hand, aquaculturalists insist that in order to compete in the live trade market on a worldwide basis restrictions must be relaxed. These calls strike at the heart of the conflict between conservation, bureaucracy and commercialisation—(1) How much can conservationists and fisheries authorities rely on private interests to respect the integrity of naturally occurring biological populations at the expense of commercial gain? (2) How much can conservationists and aquaculturalists rely upon fisheries authorities to have the ability and/or will to detect problems before it is too late? and (3) Can fisheries authorities and aquaculturalists undertake exploitation and conservation of naturally occurring populations and farmed populations simultaneously?

If regulations need to be tighter, or the aquaculture industry more controlled, the controls need to be implemented in such a way that fish farmers do not become disillusioned with the regulations and abandon
either the aquacultural enterprise, or their commitment to the need for the regulations (and carry out translocations illegally). Whatever changes are implemented in this regard they should operate in conjunction with an education programme and suitable enforcement, otherwise they are next to useless.

Given the potential damage which might result from even a single translocation event there is ample supporting evidence to suggest that education programmes and concurrent regulations be introduced (and maintained where relevant) to

(i) prevent the release of aquarium and farm held crayfish into waterways;
(ii) continue to prevent the importation of freshwater crayfish which are not native to Australia;
(iii) ensure that translocations of stock (intrastate, interstate and overseas) are declared to authorities;
(iv) ensure that disease-free status certificates and quarantine measures accompany all translocations, and that Australia-wide standards are implemented and reviewed regularly;
(v) ensure that certifiers of disease status are suitably qualified (experienced in invertebrate pathology) and do not have a vested interest in the crayfish industry.

An increase of funding (from both government and private organisations) for research into crayfish disease under wild, hatchery and pond-rearing conditions may well contribute to a heightened awareness of the potential for disease spread. Incentive schemes for farmers to declare possible disease outbreaks (such as compensation measures) may well lower the risk associated with translocations. Research should be initiated to investigate the feasibility of restricting translocations to biogeographic regions and the exportation of only farm-bred males for the live restaurant trade.

Global relevance

The recommendations given above should help insulate Australian native crayfishes from any alterations resulting from translocations of native or non-native species. They may also be of use to resource planners in countries which have already suffered from the effects of translocations, and those which intend to introduce or otherwise translocate species in the future.

In a review of the introductions of northern hemisphere crayfish, Hobbs et al. (1989) demonstrated the global magnitude of the problem. Species such as
Procambarus clarkii (Girard), Orconectes virilis and Pacifastacus leniusculus (Dana) have been moved extensively between continents and between and within countries. Many transplantations have had negative consequences; for instance P. clarkii has caused much damage to levees, dams and water control structures in agricultural areas by its burrowing activity, and it is assumed to be a vector for Aphanomyces astaci (Hobbs et al., 1989). While acknowledging the value of environmental education, Hobbs et al. (1989) conclude that prevention of further transplantations of P. clarkii will be extremely difficult because ‘...it is simply too easy for unscrupulous/misguided persons to make illegal introductions...’. The authors also suggested that developing countries be encouraged to utilise existing sources of protein rather than import non-native species.

Holdich (1987) proposes several possible solutions to ameliorate the impact of introductions, including a restriction of crayfish transport, the development of plague-resistant strains of native species, and restoration of populations of native species which have been eliminated. The last two suggestions need careful consideration since both will involve translocation. The introduction of a strain resistant to one disease should be performed only when the crayfish involved are not carrying other diseases. The biology of the parasites and symbionts on the resistant strains, and their potential impact on the native fauna if introduced, needs to be well-understood. The hybridisation potential of the crayfish should also be investigated prior to the introduction and this is particularly important for widespread species which display genetic and morphological variability over their geographic range. Thus, the introductions of crayfish for conservation purposes, such as that for restoration of populations, must be based on management strategies which are themselves founded on sound and extensive research (Lindqvist, 1987) with a view to their long-term conservation value.

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