IS THE YABBY, CHERAX DESTRUCTOR (PARASTACIDAE) IN WESTERN AUSTRALIA AN ECOLOGICAL THREAT?

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ABSTRACT

The deregulated or uncontrolled introduction of crayfish into a new area, primarily for aquaculture, may have deleterious effects on any fauna already inhabiting that same area. This discussion paper investigates the potential for Cherax destructor, introduced to the south west of Western Australia, to out-compete and displace not only indigenous crayfish, but also the critically endangered western swamp turtle, Pseudemydura umbrina. The translocation history and relevant comparative biology are presented in summary. It is suggested that the burrowing behaviour of yabbies may confer competitive advantage over native species in an area where there is decreasing annual rainfall and a receding water table.

Key words: marron, yabby, translocation, competition, cave, turtle.

INTRODUCTION

In recent decades, crayfish with aquaculture potential have been subject to inter- and intra-continental translocations. Whether the translocations were deliberate or accidental, it is unlikely that, until comparatively recently, many were made with prior concern for potential ecological impacts. The impacts, both negative (Holdich 1999) and positive (Ackefors 1999), are the subject of an extensive literature, comprehensively and thoroughly reviewed in, for example, the edited compilations of Holdich and Lowery (1988), Gherardi and Holdich (1999) and Holdich (2002).

This paper addresses two issues. One, to highlight the possible threat that the yabby, *Cherax destructor* Clark poses to: indigenous crayfish of south west Western Australia, especially marron, *Cherax cainii* Austin and Ryan; the critically endangered western swamp turtle, *Pseudemydura umbrina* Siebenrock; and to highly sensitive ecosystems such as the Eneabba caves system. Two, is to make the point as obviously as is possible, the fact that the spread of this species in Western Australia, and presumably in other countries, is not being researched sufficiently to identify possible deleterious ecological impacts before they happen. Because there is considerable variation in the spelling of the word yabby (Appendix), of Aboriginal derivation and generally denoting *Cherax destructor*, we use advisedly, for the yabby in Western Australia, the species epithet *destructor* and not *albidus*, as have, for example, Lawrence and Jones (2002).

Translocation history

The need for management strategies to gain benefits whilst minimising deleterious impacts of alien species used for aquaculture, is now recognised locally, with the Fisheries Department of Western Australia having established guidelines for managing and controlling the introduction of exotic species of aquatic fauna into local waters (Lawrence 1993).

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The translocation of marron (from Western Australia), and yabbies (from eastern Australia) across substantial natural barriers to dispersal (Fig. 1) has elicited remarkably little comment or evaluation of the likely ecological consequences. This is despite the prediction by Mills et al. (1994), acknowledged later in Holdich (1999: p. 41) that species of the Australian genus *Cherax* Clark could become "globally widespread". Even within Australia, interstate translocations of freshwater crayfish have elicited little comment – with the notable exception of the timely warnings by Horwitz (1990a, b). These species of crayfish now have been translocated extensively within Australia and around the world (Fig. 1).

There is reasonable time control concerning the history of the spread of C. destructor in Western Australia. Ten yabbies was translocated from Merwyn Swamp, near Miram, western Victoria, to the Narembeen district, central wheatbelt of Western Australia, in 1932 (Morrissy & Cassells 1992). From this foundation stock, eight were transferred in 1935 to another dam in the district. By 1969, yabbies were well established in 'most' dams of the Narembeen (Fig. 1) and had been spread to other districts nearby in the central wheatbelt, Bruce Rock, Bonnie Rock and Bencubbin (Bristow, cited in Morrissy and Cassells 1992). This area was beyond the natural geographical range of marron, and the early spread between widely spaced farm dams undoubtedly resulted from human intervention. Later, Austin (1985) recorded yabbies from 30 sites, mostly east of the Albany Highway. From late 1989 to early 1990, Morrissy and Cassells (1992) recorded yabbies in 63 of 88 farm dams sampled in eight watersheds but none from natural watercourses. Significantly, from the point of view of their spread into the geographical range of marron, all but eight of these sites occurred west of the Albany Highway (Fig. 1). Yabbies are known to be distributed now in farm dams through the wheatbelt, from Geraldton to Albany and eastwards to Esperance, with northern outlier populations inland of Carnarvon (Fig. 1). Outlier populations occur, for example in railway and mine tailing dams in the vicinity of Cue, well beyond the eastern limit of the wheatbelt.

The introduction and spread of the yabby in an area already subject to widespread colonisation by other alien species (e.g. sheep and wheat) may have seemed to be of little consequence, and may help explain why the impact of yabbies on farm dam ecosystems has not been investigated. However, of concern to us is the inexorable spread westwards and southwards (Molony, pers. com.) of yabbies into the territory of native crayfish, including the natural and expanded range of marron, and also of the western swamp turtle, *P. umbrina*. This expansion into the rivers and wetlands from Perth into the natural range of marron is continuing, probably now naturally in some cases, i.e. without the aid of human intervention. Yabbies were recorded from streams on the Swan Coastal Plain adjacent to Perth by the mid-1990s. Yabbies have been recorded from two tributaries of the Canning River near Armadale (Fig. 1), 'very abundantly' from Stinton Creek for the first time in the year 2000 in a fish monitoring program which commenced in 1991 and, possibly as escapees from an aquaculture venture, in the Southern River in 2001 (Storey, unpublished data).

Prior to their translocation, marron were restricted to deeper, permanent rivers of high water quality (Morrissy 1978). With the substantial geographical expansion within Western Australia beyond their 'natural' range northwards (Fig. 1; Morrissy 1978), marron now occur under climatic conditions quite different from those of their natural range and in a wider range of habitats, including ponds on pastoral and horticultural land, dams and streams in forested catchments (Bennet-Chambers & Knott, in press).

Ecological issues

Yabby-marron comparisons

Microhabitats of sympatric yabbies and marron in the Southern River are partitioned primarily on the basis of substrate, with yabbies burrowing into sediments with less sand and higher clay content (Lynas 2002). Further, laboratory studies showed that yabbies and marron have similar substrate preferences and that yabbies are aggressively dominant over marron of similar size (Lynas 2002). These results suggest that yabbies and marron may compete for substrate in habitats of co-occurrence and, where an overlap in limiting resource develops, yabbies will dominate these resources through interference

competition (Lynas 2002). There is also circumstantial evidence for the exclusion of gilgies by yabbies from suitable habitat in Stinton creek (Storey, unpublished data).

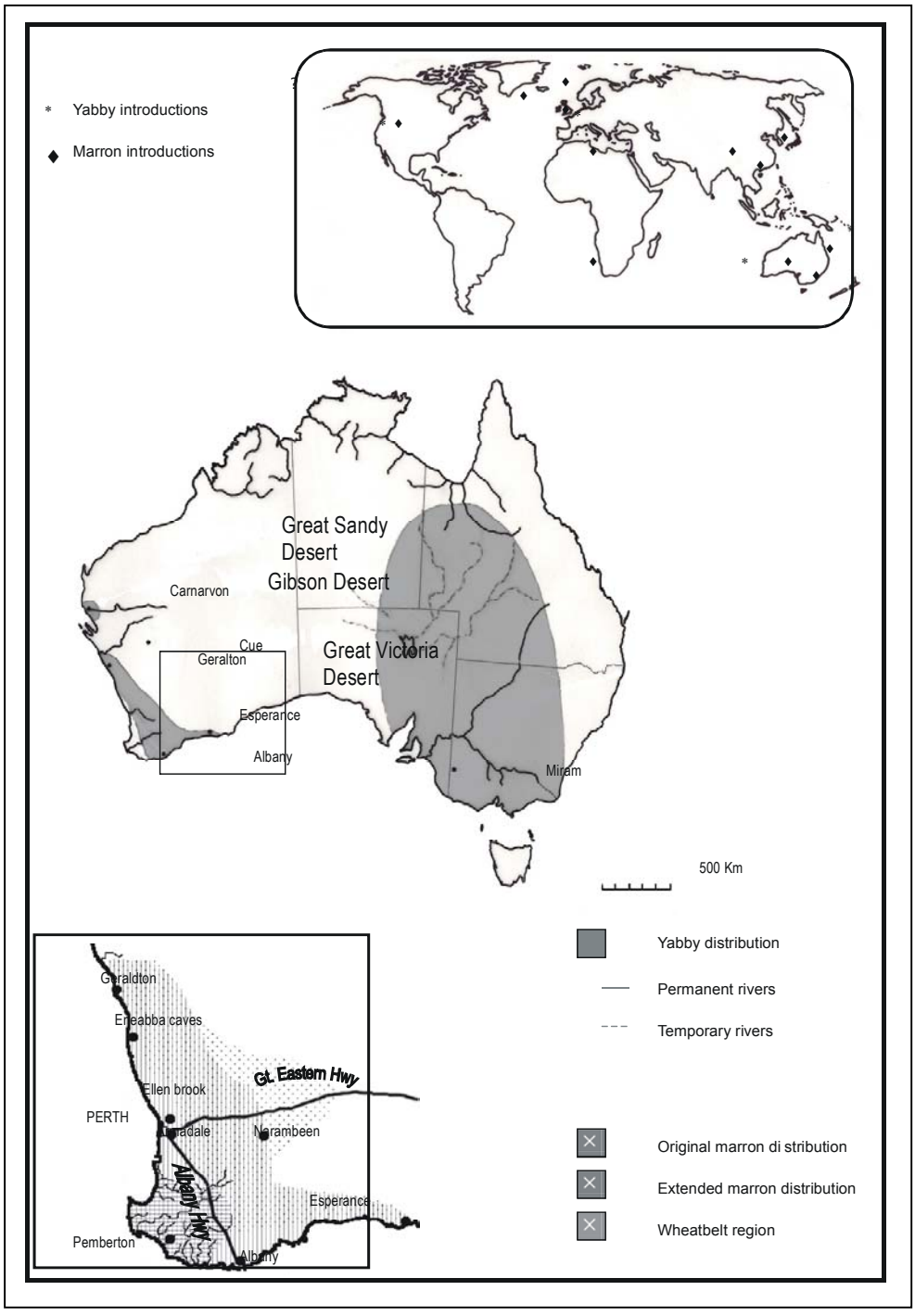

Figure 1. Maps, showing the yabby distribution in Australia (central map). The bottom insert shows the past and current distributions of marron in Western Australia, with the other main map reference points mentioned in the text also indicated. The top insert shows the world-wide distribution of *C. destructor* and *C. cainii*.

Biological attributes suggest that yabbies would be competitively superior to marron. Yabbies are "r-selected", breeding all year round, while marron are "K-selected", with a single spawning period in late spring (Morrissy 1983). Yabbies endure the temperature range 1-36 °C (Holdich & Lowery 1988); the optimal temperature range for marron is about 12 - 24 °C (Morrissy 1990). Yabbies are more tolerant of poor water conditions than marron, and attain the maximum respiration rate at dissolved oxygen (DO) concentrations of 4.0-4.5 mg l^{-1} (Morrissy et al. 1984); the maximum respiration rates of marron are achieved at DO concentrations of 5.0-6.0 mg l^{-1} (Morrissy et al. 1984). Consequently, it is reasonable to predict that in the area about Perth, the yabby is likely to out-compete the marron in terms of all of these attributes.

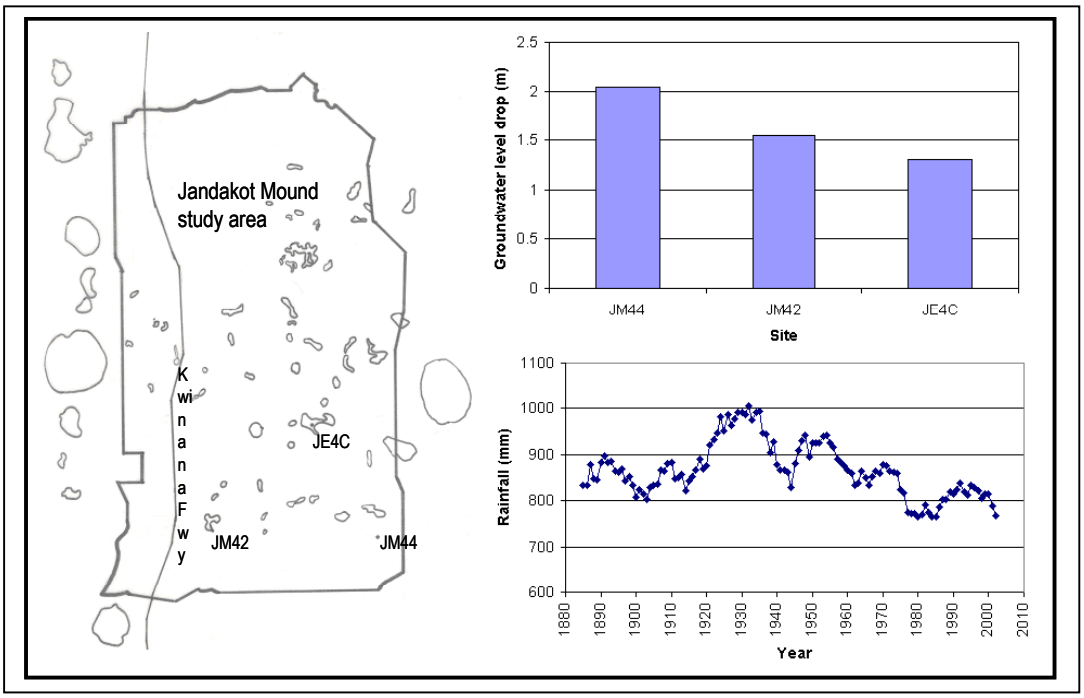

Figure 2. The total drop in metres of the water table (top) at 3 sites from the Jandakot water mound near Perth, W. A. and the overall decline in total average rainfall (moving 10 yr average) at the Perth station (bottom).

Marron require permanent surface water to survive. Although water flows are artificially maintained in the Canning River and two of its tributaries, the Southern and Wungong rivers (Allen, pers. com.), continuation of the low annual rainfall across Perth may force a revision of this management policy. Other streams in the area are becoming more temporary than they used to be with the lowering rainfall. Indeed, the outcome of interactions between yabbies and marron in streams on the Swan Coastal Plain about Perth ultimately may be determined by the climate. Annual total rainfall for the Perth metropolitan area has been steadily decreasing during the past two decades (Fig 2). Concomitantly, the water table, for example in the Canning River area, is lowering (Fig 2). As marron are considered to be not strong burrowers (Shipway 1951) it is likely that yabbies would be the more successful species in reaching a lowering water table and surviving prolonged dry periods. However, should the water table drop below the level reachable by yabbies they, too, could possibly experience local population extinctions. It is possible to be more confident of one issue, namely that the interaction between yabbies and marron is not likely to be a simple interaction to unravel. As noted above, yabbies were recorded in 2000 in high numbers in Stinton Creek, yet in 2002 no crayfish at all were found. Whatever the causes responsible for this disappearance of yabbies, it will be relevant to observe if they recolonise the waterway.

Yabby-turtle interactions

Yabbies occur in Ellen Brook, a tributary of the Swan River north of Perth (Fig. 1). Indeed, a large specimen was collected at the point where a very short, temporary runnel empties from clay swamps in Ellen Brook Nature Reserve into the Brook. Ellen Brook and Twin Swamps nature reserves were proclaimed to protect most of the remaining natural habitat of the western swamp turtle, *P. umbrina* (Testudines: Pleurodira: Chelidae). Seasonal clay swamps in the southern part of Ellen Brook Nature Reserve harbour the last, naturally persisting population of 30-40 turtles (Bradsell et al. 2002). Given the potential for the yabby to invade the reserve, Bradsell et al. (2002) investigated, in a laboratory study, the aggressive interaction between yabbies, other *Cherax* species and the much more abundant oblong turtle, *Chelodina oblonga* Gray. Marron, koonacs and yabbies all showed aggressive and predatory behaviour towards turtle hatchlings (Bradsell et al. 2002). Indeed, on two occasions, the attack by yabbies was so quick that the hatchling was killed instantly. Elsewhere, the decline of the Sonoran mud turtle (*Kinosternon sonoriense* Le Conte) in streams in Arizona, USA, has been attributed to predation by the virile crayfish, *Orconectes virilis* (Hagen) (Fernendez I think that is Fernández & Rosen 1996). There would be a wonderfully grim irony should the exotic yabby, whose spread has scarcely been challenged, eradicate the turtle despite the considerable financial and scientific resources expended on developing a captive breeding program which returns hatchlings to the wild. In the period 1992-2002, the western swamp tortoise recovery team spent an estimated 1 million AUD (Burbidge & Kuchling 2000) with projected spending of more than 1.3 million AUD in the period 2003-2007 (Burbidge & Kuchling 2002).

Subterranean yabbies

Finally, the propensity of yabbies for spreading and exploiting a range of habitats is exemplified by their discovery in caves near Eneabba (Fig. 1; Jasinska et al. 1993), north of Perth. The caves occur in sandy heathland with only subterranean drainage, connected to the east with temporary surface drainage. The yabbies probably had escaped from a farm pond via the temporary surface drainage into the cave. Of concern was the number of crayfish present; clearly a breeding population had become established, and the yabbies were undoubtedly feeding on the native animals normally resident in the cave streams. However, the impact has not been assessed. Perhaps it is worth noting here that yabbies obviously cannot read: the caves occur in a national park, which should be off-limits to exotic fauna!

Economics vs environment

The expanding distribution of yabbies in Western Australia is not viewed by everyone as a potential ecological disaster waiting to happen, but instead has received strong endorsement by those farmers who have been in the position to capture the benefits of having a new cash crop on their farms with minimal research and outlay required. Production of yabbies increased from 1.5 t (in 1987) to 211 t by 1999/00, worth an estimated 2.78 million AUD (Brasseur & Maguire 2001). Intially, the spread was facilitated unwittingly by farmers, many of whom believed that the crayfish were koonacs, *Cherax preissii* (Erichson), a Western Australian endemic (Morrissy & Cassells 1992). A Rural Education Aquaculture Program of Curtin University promoted yabby production in the late 1980s. Yabbies for home aquaria have been distributed through the Perth Royal Show and are available live in other places such as suburban fish markets (Lindhjem, pers. obs. December 2002). Hence, it must be concluded that the spread of the yabby in Western Australia generally has not been regarded as threatening.

The spread possibly also was facilitated through a lack of government departmental response. By the 1970s, the Fisheries Department of Western Australia was aware that yabbies occurred in dams through a wide arc of the hinterland from Geraldton to Esperance (Morrissy & Cassells 1992), yet the Fisheries Department did nothing to warn against the spread. The first warning was issued by Chris Austin in a letter to the Director of Fisheries in August, 1985, in which Chris specifically raised concerns about the interaction between marron and yabbies (Morrissy and Cassells 1992). The Minister for Fisheries responded by issuing a press release warning of the dangers of introducing yabbies. Under part IV – Miscellaneous, Section 36A, Fisheries Act of Western Australia, a species may be declared as noxious, allowing control over use and spread of the species; Section 36B allows for eradication of a species. However, the eradication of the yabby was not considered an option in Western Australia, (a response

that contrasts markedly with the attempt to eradicate *C. destructor* from Tasmania when discovered there, albeit with limited success.) A measure of control was pursued under Fish Farming provisions of the Fisheries Act, limiting the licensing of yabby farming to the area east of the state forested line boundary (previously the Albany Highway) and 'north' of the Great eastern Highway in Perth, (Lawrence, pers. com.). The intention of the western boundary was to restrict the spread of the introduced yabby into the natural range of native crayfish, while the northern boundary of the great eastern highway was implemented to prevent the transmission of *Thelohania* spp. to endemic crayfish (Lawrence, pers. com.). However, whilst the Fisheries Department actively discourages the stocking of yabbies within the natural habitats of native marron, koonacs and gilgies, there is no legislation enabling prosecution of offenders (Sheffield, pers. com.).

It is apposite to digress here to cite another introduction, without appropriate investigation of the likely impact on natural ecosystems, of alien crayfish for aquaculture. Red claw, *Cherax quadricarinatus* (von Martens), recently has become established in the Kimberley region of northern Western Australia in Lake Kununurra, a RAMSAR wetland of international importance. This species, endemic to northern Australia, was introduced to enclosures adjacent to Lake Kununurra for aquaculture. Subsequently, specimens apparently have escaped from the aquaculture ponds and have become established in the lake. Currently (October/November 2002) mature crayfish are being taken from Lake Kununurra by recreational fisherpersons (McIntosh, pers. com.). The impacts of red claw on the ecology of Lake Kununurra are unknown. Furthermore, it is likely that the species will spread downstream to the lower Ord River, and eventually to Parry Lagoon, another wetland of RAMSAR importance on the Ord River floodplain. Again, the implications for the ecology of the systems are unknown, however, three species of *Macrobrachium* prawns, two native (*Macrobrachium australiense* Holthuis, *M. bullatum* Fincham) and another currently classified as the widespread *M. rosenbergii* (de Man) but in reality likely to be a new, as yet undescribed endemic species, and three species of atyiid shrimp (*Caridina cf. longirostris*, *C. nilotica* P. Roux and *C. serratirostris* de Man) all may be under threat. Red claw escapees from the large aquaculture scheme currently being developed on the Dunham River, a major tributary of the Ord River, with its confluence downstream of Lake Kununurra may well exacerbate negative ecological impacts in significant wetlands of the Ord River floodplain. The Dunham River scheme, and the earlier introduction into Lake Kununurra, have proceeded, apparently with the knowledge of the Fisheries Department.

Sadly, perceived economic benefits, not fully costed, have proceeded with little regard to the possible conservation issues. With reductions in water resources on the Swan Coastal Plain, presumably there will be an associated increase in stresses for the aquatic fauna, and under such stressful conditions the competitive abilities of species will be tested to the extreme. It would be a great pity indeed if the marron, a species rightfully regarded as a flagship for the state (Nickoll & Horwitz 2000), succumbed even in an area where it too might be exotic, because of ignorance of the direction and outcomes of the competitive interactions between marron and yabbies. Clearly the Fisheries Department should take a stronger position on introductions rather than permitting aquaculture ventures using introduced species without sufficient research into possible ecological impacts. Legislation allowing for prosecution and fines for the release of alien crayfish in European countries has been implemented (for example, Pöckl 2002) and should be considered for Western Australia.

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APPENDIX

Evidence of the importance of crayfish for the Aborigines of each area is indicated by the rich repertoire of vernacular names of Aboriginal derivation, particularly that known as the yabby, yabbie, yabbee, yabber (there seems to be no one 'correct' spelling, although Morrissy (pers. com.) did acknowledge using yabbie until he was persuaded to change to yabby in the 1990s). The compilation here is extracted from Hart (1994).

Yabbee, yabber, yabbie, yabbity, yabby, yobbi, yobbie: derived contemporary words.

Probably referring to *C. destructor*

Acheroo, andar, ander, boogalli, boogarli, bookill, bookillee, bowgili, buggilla, bugili, cuinci, cunder, danibutcha, geary, iltjanma (= the crayfish ancestor), iltjanmalitnjaka (= place where the crayfish had dug.), iltjénma, inga, ingar, injíltjinjíltja, inka, inkka, ityanma, jabby, jabid, jabidj, jakalaan, kakine, kandera, karkoora, kary, koon-da-chi, koondagi, koongideri, koongoola, koongoolo, koonkooderi, koonkoodirri, kunggurla, kuniekoondie, kuniekundi, kuntatyi, kurnkuderri, kurukudirri, kutera, lippekil, ltyanma, mamaroo, mamuru, marooroo, mokin, mulpo, mundi, munya, muracuru, narraminyeh, ngaltaitye, ngobbera, oovarroo, pe-kool, pikquol, pirrinoo, quarra, quarroo, reri-reri, tararukau, thandoola, thandulya, thinta, thoombur, thornabun, thumal, toomban, trunagi, tumpan, tunanyty, umpurra, unde, wegiga, winga, wolkoo, worronguna,

Probably referring to *C. destructor* ± *Engaeus* + others

bamban, baranjak, barranjerk, barrinjook, beekodl, boagalli, bogally, boligar, boogal, boogali, boogurrie, carrda, dookami, enkodko, eukodko, gadjunja, (gadunja), gidda, gidyar, gungulu, ilidja, inundah, kandura, kapich, karee, karkoora, keler, kidneykooderi, koarow, konkro, kongola, koongala, koongooloo, koon-gooloo, kumbooloo, mamuru, mangaba, maraija, maramie, marramin, marooroo, meauki, moak, monagur, moorogonong, mooroonong, moramy, morramma, munya, murangir, murragolong, nadan, naingan, nark, notkun, ringwong, tchoriong, thandulya, thangambooloa, thappooll, thupul, tinungi, ukodko, ukot, weechuk, wiija, wolona, wolonuk, wurenag, yaabitch, yaam, yaapitch, yabbechi, yabij, yampit, yaparte, yapi, yapit, yapitch, yappee, yappi, yappitch, yappy, yarrun, yukalto.