Department of **Agriculture and Fisheries**
Biosecurity Queensland

Invasive animal risk assessment

Pacific rat

Rattus exulans

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Queensland Government

Photo: McCormack (2007), used with permission

Contents

Summary

Rattus exulans (Pacific rat) is very similar to, but smaller than, *Rattus rattus* (ship rat) and *Rattus norvegicus* (Norway rat/brown rat). While the last two congeners are widespread and abundant in Australia, *R. exulans* has failed to naturalise on our mainland. Although *R. exulans* was recently reported on an island in the Torres Strait, a naturalised population has not been confirmed anywhere in Queensland. The origin of *R. exulans* is obscure, but it is probably native to South-East Asia.

R. exulans is an invasive pest on numerous islands across the Pacific, where it has significant negative impacts on native vegetation and wildlife populations, particularly invertebrates, lizards and ground-nesting seabirds. It is also a major agricultural pest in South-East Asia and the Pacific, damaging rice, sugarcane, banana, cacao, coconut, maize, passionfruit, pawpaw, pineapple, mangoes and root crops.

This risk assessment presents evidence that *R. exulans* has several key attributes that confer significant pest risk in Queensland: 1) a history as a major pest overseas, 2) a preference for tropical, subtropical and warm temperate climates (climate match) and 3) an extensive global distribution. However, a conclusion of 'high pest risk' carries considerable uncertainty, since *R. exulans* is expected to face strong competition for resources from larger congeners (especially *R. rattus*, *R. norvegicus* and *R. sordidus*). Despite such uncertainty, negative impacts on biodiversity and certain crops cannot be ruled out. Climate modelling suggests that climate along the northern coast of Queensland is highly suitable for the species.

More research on the competitive relationship between *R. exulans* and its larger congeners is required before more robust conclusions on risk can be made.

Introduction

Identity and taxonomy

Species: *Rattus exulans* Peale 1848

Synonyms: *Mus exulans* Peale 1848, *Mus maorium* Hutton 1877, 1879

Common names: Polynesian rat, Maori rat, kiore

Order: Rodentia (Family: Muridae)

Ellerman (1941, 1961) and the Global Biodiversity Information Facility (n.d.) list multiple subspecies. However, a number of subspecies have been dismissed as junior synonyms of *R. exulans* (Corbet & Hill 1992; Musser & Carleton 1993). Motokawa et al. (2004) did not recognise any subspecies.

Description and biology

R. exulans is generally 80–140 mm long (plus 108–147 mm tail) and weighs around 30–180 g (Long 2003) (Figure 1).

Figure 1. Adult Pacific rat (*R. exulans*) (Photo: McCormack (2007), used with permission)

Its tail is either the same length or slightly longer than the body. Fur colour on its back and sides is brown to grey-brown with spiny black guard hairs. However, its belly fur is grey with white tips. Its tail is dark grey with bristles that give the appearance of faint, narrow rings. A key diagnostic feature is a small area of dark hair on the outer edge of the hind feet near the ankle (Figure 2).

R. exulans is the smallest of the three most invasive rat species widely associated with people (*R. rattus*, *R. norvegicus* and *R. exulans*). Juvenile *R. rattus* (black rat or ship rat) are very similar in appearance to adult *R. exulans* (Figure 2), but adult *R. rattus* are larger (95–340 g).

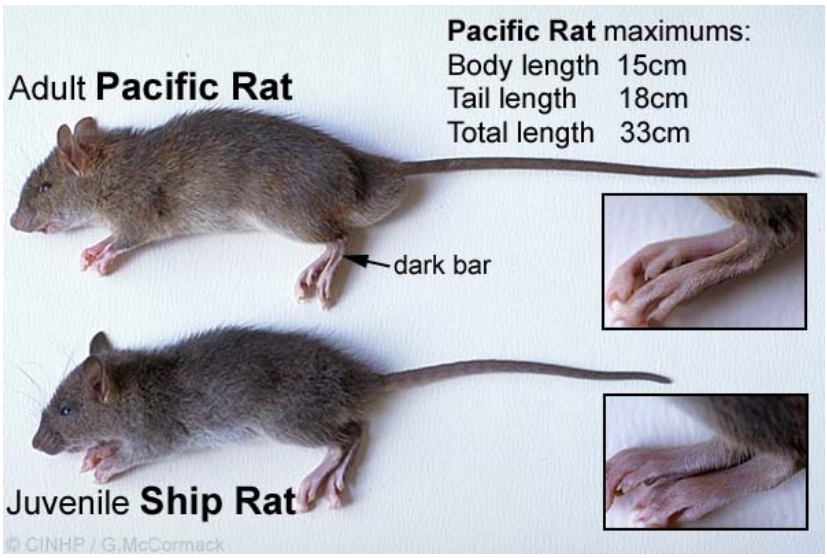

Figure 2. Comparison between adult Pacific rat and juvenile black rat (Photo: McCormack (2007), used with permission)

Morphology (skull size) of *R. exulans* varies with latitude (with reference to Bergman's rule: geographic races of species with smaller body size are found in warmer parts and larger body size in colder parts of the species' range) and island size. This effect is most pronounced in the tropics (Atkinson & Towns 2001).

Behaviour

R. exulans is generally nocturnal (Long 2003), although it can be crepuscular or diurnal on occasions. It spends most of its time on the ground but is capable of climbing trees. Males and females associate for mating but are otherwise solitary. The species is sedentary, with home ranges varying from 237–1845 m^2 (often 200–280 m^2) (Long 2003). Density varies depending on environmental conditions from 6 to 188 animals per hectare (Long 2003). It can swim up to 200 m (*R. rattus* can swim 500 m and *R. norvegicus* up to 2 km).

Diet

R. exulans is omnivorous and highly opportunistic, eating seeds, flowers, fruits and other plant parts, a wide range of invertebrates (snails, insects, earthworms, spiders, ants etc.), lizards and birds (eggs and juveniles). On Lady Alice Island, New Zealand, research found that the diet of *R. exulans* comprised 78 per cent plant material, with the remainder made up of a wide range of animal food, including weevils, scarab beetles, moth larvae, weta, seabird chicks and skinks (Atkinson & Towns 2001). *R. exulans* often carry their food to small 'feeding stations', which provide shelter from predators, competitors and the elements.

It is not clear whether the diet of *R. exulans* is more or less specialised than *R. rattus*. However, a study on Eniwetok Atoll, Marshall Islands, suggested that *R. exulans* utilised a narrower range of foods compared to *R. rattus* (Fall et al. 1971).

Reproduction and dispersal

Breeding occurs throughout the year with a peak from October to June. However, in New Zealand, breeding is from September to March. There can be 1–6 litters per year, but commonly 3–4 (the species is polyestrous). Litter size depends on the availability of food but is usually around 4 (varies from 1 to 11). Gestation is 21–24 days. Young are born in a neat, spherical nest, usually constructed on the ground among debris, but sometimes in a tree. Average life expectancy in the wild is less than 1 year and on average only 6 months. Populations are often irruptive, every 3–5 years (Long 2003), depending on food availability and a range of other factors.

Origin and distribution

R. exulans is not indigenous to Australia but has established populations in the wild on islands here and elsewhere in Asia and on numerous islands across the Pacific (Figure 3). Long (2003) provides a comprehensive list of islands that support populations of *R. exulans*.

Since *R. exulans* tends to be closely associated with people and is often accidently transported to new areas when people move their possessions. As it has been 'hitchhiking' with people for centuries, its native origin is now obscure. However, its native range is believed to include southern and South-East Asia, from eastern Bangladesh, the Andaman Islands, Burma, Thailand, Vietnam, south to the Greater and Lesser Sunda Islands (Sumatra to Timor), Papua New Guinea, New Britain and the Philippines (Long 2003). It is the third most widespread rat species in the world, after *R. norvegicus* and *R. rattus*.

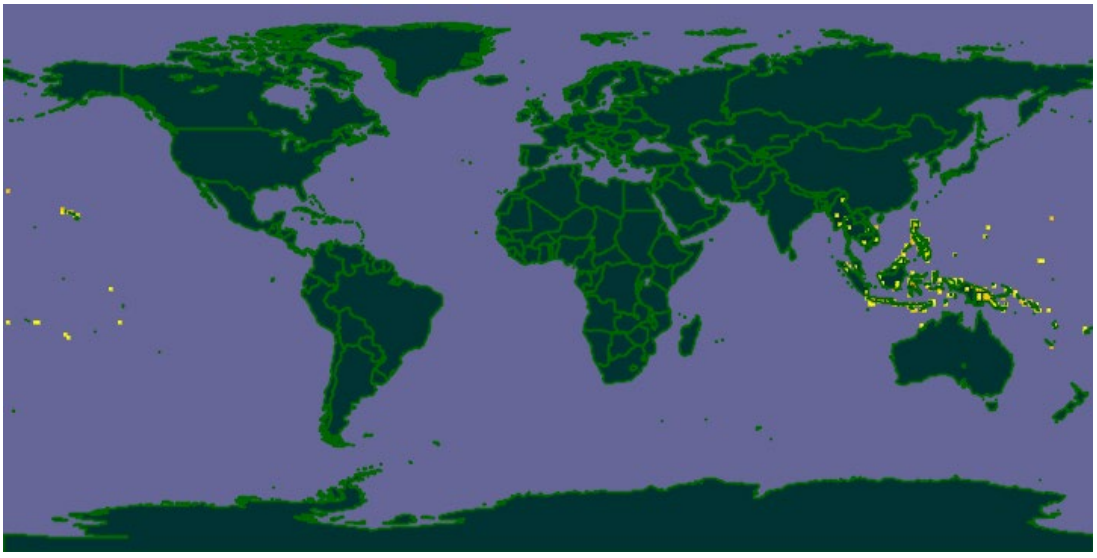

Figure 3. Global distribution of *R. exulans* (Global Biodiversity Information Facility n.d.)

R. exulans was introduced to many Pacific Islands, including Hawaii and New Zealand, by early Polynesian colonists, possibly as early as 800–1400 AD. The rats were carried as a source of food, together with pigs, dogs and chickens (Barnes et al. 2006).

Stowaways on vessels are still considered the most likely source of potential incursions into Australia.

Preferred habitat

R. exulans often becomes abundant when living in close association with people in and around villages, houses, cultivated fields, rice paddies, coconut plantations and cane fields. While perhaps preferring relatively open, disturbed sites that have adequate cover, including grasslands, scrub and secondary forest, *R. exulans* can also persist in less disturbed areas, including mature forest and offshore islands. The availability of sufficient food and shelter appears to be the key requirement, rather than habitat type in itself. For example, Harper et al. (2005) found that on Stewart Island, New Zealand, *R. exulans* was most abundant in areas with 'large amounts of ground cover'. Adequate cover is believed to be required either as protection from predators (Atkinson & Moller 1990) or to help avoid competitive interaction with larger congeners (Falkenberg & Clarke 1998).

Preferred climate is also very broad, from tropical to temperate, generally in high-rainfall areas, but extending into seasonally dry areas, across an extraordinary latitudinal range from the highlands of New Guinea to New Zealand. Dwyer (1978) commented that, in the highlands of New Guinea, *R. exulans* 'emerges as a pioneer and opportunistic species able, in the absence of other rodents, to exploit a diversity of habitats (grassland to rain forest), able to tolerate strikingly different climatic regimes, able to persist for long periods at low densities and at times breaking out in virtually plague proportions'.

History as a pest elsewhere

The Pacific rat is considered a major pest of agriculture in South-East Asia and on islands throughout the Pacific, damaging rice, sugarcane, banana, cacao, coconut, maize, passionfruit, pawpaw, pineapple, mangoes and root crops (Long 2003; Global Invasive Species Database 2010). While most damage is from consumption of seeds and fruit, *R. exulans* also chews on the plant's stems, weakening the plant and exposing it to infection and disease. In Hawaii, damage to sugarcane crops is conservatively estimated at $6 million per year (Tobin 2005).

R. exulans is a significant environmental pest on islands throughout the Pacific. It competes with local native wildlife for food and is a significant predator of birds, lizards and insects. It has been implicated in a number of species' extinctions on islands in the Pacific. There is also speculation that *R. exulans* consumed the seeds of the dominant palm tree species on Easter Island, facilitating the island's deforestation and the ultimate demise of its society. Similar catastrophic impacts on Hawaii's lowland rainforest have also been suggested (Athens 2008).

On some of New Zealand's offshore islands, populations of certain ground-nesting birds (mainly seabirds), lizards and large flightless invertebrates declined following invasion by *R. exulans* (Atkinson & Towns 2001). More specifically, *R. exulans* is considered responsible for the extinction in New Zealand of the greater short-tailed bat due to predation and/or competition for food. On Norfolk Island, predation of the eggs of burrow-nesting providence petrel and Pycroft's petrel by *R. exulans* caused both species to become extinct on the island. Similarly, *R. exulans* was a major factor in the demise of the kaka parrot, Norfolk pigeon and Tasman starling. On Henderson Island (Pitcairn Islands), *R. exulans* is a major predator of the chicks of three species of petrels. On Green Island, in Hawaii, it has been observed killing adult nesting Laysan albatross. In Hawaii and New Zealand there are examples of detrimental

effects on burrowing petrels, red-tailed tropicbirds and shearwaters (Pierce 2002). In the Leeward Islands of Hawaii, predation on seabirds only becomes significant after storms have reduced the fruiting of food plants. Fatal attacks on adult Laysan albatross appear to be associated with the same factor. More detailed information on the impact of *R. exulans* (and other rat species) on birdlife in the Pacific is provided by Varnham (2010).

R. exulans is known to browse native flora (including trees, shrubs, fungi, sedges, grasses, orchids and other herbaceous plants and lianes), although the significance of such browsing has been difficult to assess (Atkinson & Atkinson 2000). In New Zealand, the recruitment of at least 11 tree species has been reduced as a result of *R. exulans* eating plant parts, seeds and seedlings. Some tree species have become locally extinct. Similarly on certain Pacific islands, *R. exulans* has affected populations of at least 15 threatened plant species, by eating plant parts and damaging their bark.

While having significant impacts in certain areas, *R. exulans* is generally considered less of a problem (globally) than *R. rattus* and *R. norvegicus* (Varnham 2010).

On Viwi Island, Fiji, *R. exulans* enters people's homes, eating their food and even biting people in their sleep.

Expensive eradication programs have been undertaken on many islands in New Zealand and across the Pacific. While the introduction of *R. exulans* into New Zealand by the Maori resulted in the extinction of several species of terrestrial and small seabirds, recent control programs have resulted in substantial increases in populations of certain seabirds and endemic terrestrial birds. As part of its program to restore populations of seabirds and endemic terrestrial birds such as the endangered kakapo, the New Zealand Department of Conservation undertakes programs to eliminate *R. exulans* on most offshore islands under its jurisdiction and other conservation groups have adopted similar programs elsewhere. However, two islands, Mauitaha and Araara, were set aside as sanctuaries for the rat.

Pest potential in Queensland

Current distribution and impact in Queensland and Australia

R. exulans has existed on Norfolk Islands for centuries, on Christmas Island since around 1887 and on Adele Island (north of Derby in Western Australia) since 1891 (DAFF n.d.). Introduction on Adele Island is believed to have occurred with the movement of fishing vessels from Indonesia. There is an early record on Murray Island (Mer Island) in the eastern Torres Strait dated 1888–89, where *R. exulans* may have been introduced by canoeists from Papua New Guinea; a recent incursion onto Mer Island was suspected. However, searching has failed to confirm its presence. It may also occur on Sunday Island (off Western Australia) (DAFF n.d.).

R. exulans is believed to be absent from mainland Australia.

Potential distribution and impact in Queensland and Australia

The climate-matching software Climatch (Bureau of Rural Sciences 2009) was applied to predict areas of Queensland where climate is similar to that experienced across the native and naturalised range of *R. exulans*. Most of coastal Queensland appears to offer favourable climate for the species, with the northernmost tip of Cape York appearing to be most suitable

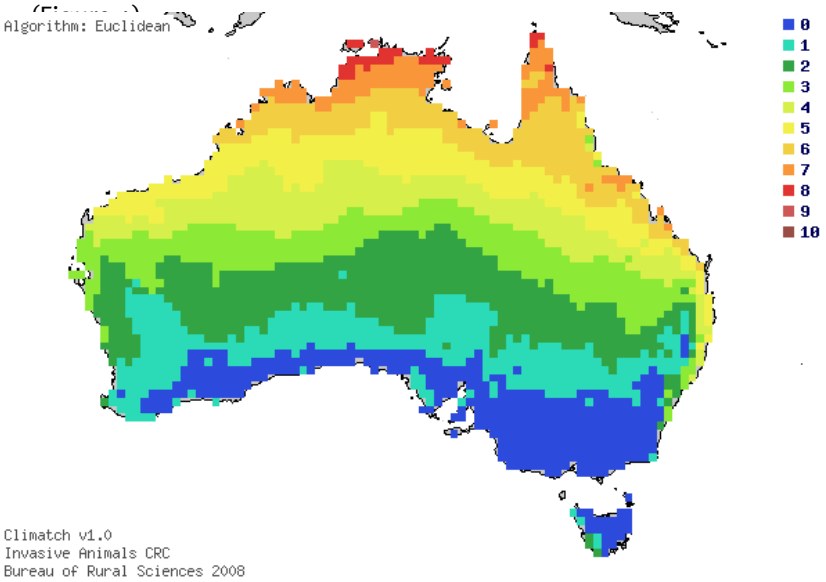

Figure 4. Areas of Australia where climate appears suitable for survival of *R. exulans*. Red and dark orange are highly suitable, light orange and yellow are marginally suitable, and green, blue and white are unsuitable. Map produced using Climatch computer software (Bureau of Rural Sciences 2009)

A risk assessment of *R. exulans* conducted by the Western Australian Department of Agriculture and Food concluded that the species poses an 'extreme' threat to Australia, the highest of four categories. The assessment suggested that *R. exulans* is 'highly likely' to establish populations in Australia, considering its biology, history as a pest elsewhere and the similarity between climate in tropical Australia and elsewhere in its naturalised range.

Similarly, this assessment presents evidence that *R. exulans* has several key attributes that confer significant pest risk in Queensland:

- a history as a major pest overseas
- a preference for tropical, subtropical and warm temperate climates (climate match)
- an extensive global distribution.

However, a conclusion of 'high pest risk' carries considerable uncertainty, since *R. exulans* is expected to face strong competition for resources from larger congeners (especially *R. rattus*, *R. norvegicus* and *R. sordidus*), as discussed below.

The question of whether *R. exulans* could persist in Queensland when faced with strong competition from other rodents is difficult to answer. The larger congeners *R. rattus* and *R. norvegicus* are known to successfully displace *R. exulans* from certain environmental niches

(Spennemann 1997) and have largely outcompeted *R. exulans* over much of its global range (Atkinson 1985; Long 2003; Varnham 2010). Moreover, *R. rattus* is regarded as the 'superior competitor of the three species' in New Zealand (Russell & Clout 2004). For example, over 20 years, *R. rattus* replaced *R. norvegicus* as the dominant invasive rat species in the Bay of Islands archipelago in New Zealand (Moller & Tilley 1986; King 2005; Russell et al. 2008). *R. norvegicus* had previously replaced *R. exulans* from the North Island of New Zealand (Long 2003). However, Dwyer (1978) commented that the degree to which *R. exulans* tolerates other *Rattus* species varies 'markedly through the range (e.g. Williams 1973) without any clear patterns that may be tied to geographic or climatic gradients'. Similarly, Tobin (2005) commented that *R. exulans*, *R. rattus* and *R. norvegicus* coexist throughout much of the Pacific basin and 'it is not known how much, if any, interspecific competition exists'. Following the arrival of *R. norvegicus*, *R. rattus*, and house mice (*Mus musculus*) in New Zealand, populations of *R. exulans* declined (*R. exulans* was a much earlier arrival). Today, *R. exulans* is 'very rare' on the two main islands. Tobin (2005) also commented that 'It is not clear whether a similar decline occurred in Hawaii, but if so, Polynesian rats (*R. exulans*) have adjusted. Today, they are the most abundant lowland rat in many parts of the state'. A study on Stewart Island (New Zealand) found that *R. exulans*, *R. rattus* and *R. norvegicus* coexist on the island but utilise different habitats (Harper et al. 2005). *R. rattus* dominates podocarp-broadleaf forest and riparian shrubland. *R. norvegicus* dominates subalpine shrubland and *R. exulans* dominates manuka (*Leptospermum scoparium*) shrubland. Hence, the latter study suggests the three species can coexist and achieve so-called resource partitioning within a given area. The degree of coexistence presumably varies in response to numerous variables, especially climate, habitat type and size.

If *R. exulans* naturalised in coastal North Queensland, it would not only face potential competition from *R. norvegicus* and *R. rattus* but also *R. sordidus* (canefield rat) and *Melomys burtoni* (grassland melomys), both abundant pests of sugarcane. There appears to be considerable habitat and dietary overlap between these species. The level of interspecific competition is impossible to predict, but will influence the potential abundance of *R. exulans* and, therefore, its impact. There is a possibility that *R. exulans* could fail to naturalise, due simply to competition from established congeners. This might explain why it has failed to naturalise to date, given seemingly ample opportunities for introduction.

Most of the international literature describing the impact of *R. exulans* involves islands in the Pacific. Hence, this study speculates that *R. exulans* may be more of a risk to Queensland's small offshore islands, where it might be better adapted, than to mainland habitats. On such islands, populations of invertebrates, lizards and ground-nesting birds are at risk, based on experience from overseas. Again, such impacts may be dependent on interaction with established congeners.

Since *R. exulans* has negative impacts on a range of crops, including sugarcane, banana, maize, passionfruit, pawpaw, pineapple, mangoes and root crops in Asia, similar impacts on these crops in Queensland cannot be ruled out.

More research on the competitive relationship between *R. exulans* and other rodents within mainland habitats is required before more robust conclusions on risk can be made.

Potential impacts on human health appear no worse than other *Rattus* species, with the risk of leptospirosis being perhaps most significant. Similarly, the risk of creating an urban nuisance (chewing electrical wires, damaging stored foodstuffs etc.) is considered comparable to *R. rattus*.

Risk of introduction

R. exulans is likely to arrive in Queensland onboard ships from Asia and the Pacific. This assessment speculates that *R. exulans* may have arrived on numerous occasions in the past, but has failed to naturalise due either to small initial population size or competition from established rodents.

Feasibility of eradication

Over the last 15 years, small populations of *R. exulans* have been successfully eradicated from some of New Zealand's offshore islands. The largest island freed from *R. exulans* is Raoul Island at 2938 ha. Eradication has also been attempted on Little Barrier Island (3083 ha) (Global Invasive Species Database 2010) and elsewhere. Eradication is usually achieved using poisons. More detailed information on eradication programs in the Pacific is provided by Varnham (2010).

If detected early, eradication of *R. exulans* would be an option on Queensland's offshore islands, particularly in cases where an island is smaller than around 3000 ha. Eradication from larger islands would be much more difficult and expensive. Eradication from the mainland is unlikely, unless the population is detected very early.

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