6 Discussion of risk quantification and recommendation for management of tropical fire ants at Ashmore Reef

6.1 Results summary

1. The density of dead common noddy chicks and tropical fire ants, and the percentage cover of vegetation, were similar between East and Middle Islands. However, the density of dead chicks in the smallest, most vulnerable age/size class (Class 1) was 3.9 times higher on Middle Island than on East Island.
2. Across both islands, the density of dead common noddy chicks increased with an increase in the density of tropical fire ants, and decreased with increasing amounts of vegetation cover. The combined relationship was highly significant and explained 26% of the variability in the spatial data set. However, this general relationship differed in a complex manner between Middle and East islands.
3. The negative effects of vegetation cover and the positive effects of tropical fire ant density on the mortality of common noddy chicks across both islands were greatest (& significant) for the first two size/age classes. The explanatory power of ants and vegetation cover increased to 38% when the combined mortality data for the first two size classes were only used.
4. However, the effect of tropical fire ants was only statistically evident on Middle island and, in contrast, the effect of vegetation cover was only statistically evident on East island. The contracted relationships increased the explanatory power of vegetation effects on East island to 58% and, that for the effects of tropical fire ants on Middle island, to 38%.
5. Taken together, results 1, 3 and 4 above indicate that the impact of tropical fire ants on the mortality of common noddy chicks in the more vulnerable age/size classes (1 & 2) was far greater on Middle Island than on East Island, providing a fortuitous study "control" to differentiate the effects of tropical fire ant mortality from natural mortality.
6. The four age/size classes of common noddy dead chicks were recombined to create two vulnerability classes to tropical fire ant predation (Classes 1 & 2 vs. 3 & 4). The mortality rates of the more and less vulnerable classes of chicks on East Island was 59% and 41% respectively, and that for Middle Island 73% and 27%, respectively.
7. The isolated mortality rates of each vulnerability class attributed to natural agents and tropical fire ants were then estimated by assuming that mortality on East island was mostly natural. The mortality rate of the smaller and more vulnerable age/size class of chicks attributed to tropical fire ants on Middle island was 34% and, that for the larger and less vulnerable class, 11%. However, these estimates depend on the assumption that natural mortality rates between the two islands are similar.
8. The mortality of older chicks on Middle Island was 14% less than on East island, however, we assume that fewer birds died in the older age class on Middle Island because there were fewer of them. That is, they simply died in the previous younger age class due to ant predation, not because survival was better in the older age class.

9. The reason for the complex interactions between ants, cover of vegetation and common noddy mortality between islands is unknown and requires further study. However, the additional mortality of nestlings attributed to tropical fire ants would undoubtedly have a significant long-term impact on common noddy populations if continued unabated.
10. The seriousness of the situation is underscored by two facts: tropical fire ant populations have the potential to erupt to very high levels, thereby substantially increasing present mortality rates; and, of all seabirds that nest on Ashmore Reef islands, the common noddy is probably one of the least susceptible species to tropical fire ants. There is evidence that, if nesting failure occurs, this species will re-lay up to three times (Gibson-Hill 1947), whereas the same might not happen for sooty tern. Replacement of lost clutches is low in species such as the boobies, as the clutch can constitute over 8% of the female's weight (Carboneras 1992).

There are several further factors that need to be considered and could not be investigated or quantified during this study:

1. Despite there being no direct evidence of attack of tropical fire ants to lesser frigatebirds, this species, as in a number of other seabirds, has a breeding cycle that is not necessarily annual (Lindsey 1986). Therefore, potential risks of nesting failures should be taken into consideration and avoided.
2. No information on potential impacts from tropical fire ants on sooty terns could be gathered. At the time of sampling this species was not breeding, and evidence from the previous nesting season (ie dead chicks) was unavailable. The sooty tern is a ground nesting species and utilises the same breeding sites as the common noddy at Ashmore Reef. Sooty terns reach sexual maturity around 8 years of age, and as such, any protracted impact on breeding success over several seasons could potentially pose a serious threat to long-term recruitment and, hence, abundance. From previous estimates of numbers of breeding pairs at Ashmore, and from recent counts undertaken during the bird surveys in November 2004, the Ashmore Reef colony of sooty tern may be the largest in Western Australian waters.
3. Regardless of the more quantitative results of this study summarised above, there remains major knowledge gaps on the population ecology of all nesting seabirds on Ashmore Reef islands, at both global and local scales, that will limit interpretation of how 'significant' the effects of tropical fire ants really are. Hence, conclusions and recommendations should be treated with caution and are preliminary at best. For example, even if noddy tern mortality at Ashmore Reef due to tropical fire ants was 100%, the significance of this to world-wide populations is unknown because the global importance of this recuitment node is unknown. The answer to this question is obvioulsy beyond the scope of our study and, although we cannot give a 'global' perspective to such 'open populations' of seabirds, we adopt the precautionary principle in our risk assessment and conclude that the impact of tropical fire ants to nesting seabirds on some Ashmore Reef islands will most likely be significant. Desktop studies using Population Viability Analysis (PVA) or similar population simulation methods will deviate very little from this conclusion with respect to Ashmore, but is recommended as an extension to this study.
4. Nevertheless, at more local island-habitat scales there is an almost complete lack of knowledge of basic population ecology of all seabird species and this should be re-dressed for their future management regradless of type of risk. For example, what are the factors that influence nesting success, clutch size, hatching success, survival of nestlings to fledglings, and returning breeding adults? and; how do natural mortality rates interact with tropical fire ant induced mortality rates (ie additive or compensatory)? During the

September 2004 ant surveys at Ashmore Reef islands, tropical fire ants were observed feeding on injured and unhealthy common noddy adults. Several studies have documented reduced breeding performance (including clutch size, provisioning rates, and the growth and survival of off-spring) as a result of increased foraging effort by adults (Hunt 1972; Lemmetyinen 1973; Davoren and Montevecchi 2003). Lack, or poor quality of, food resources available at sea to breeding adults (see climate change effect over long term) could result in more chicks being weak or unhealthy and as such more likely at risk from tropical fire ant predation.

6.2 Management strategy

The results of this assessment demonstrate clearly that understanding the interrelationships between tropical fire ants and their impacts on biodiversity at Ashmore is a complex task, requiring further quantitative work.

Three management strategies could be adopted in order to control the tropical fire ant at Ashmore:

- eradication;
- control to some target density;
- no action

We provide recommendations below for the management of tropical fire ant impacts at Ashmore, by addressing each management strategy listed above, and by describing risks and issues associated with different management actions.

6.3 Eradication

The relatively small size and contained nature of terrestrial island ecosystems can represent opportunities for the management of invasive alien species that are better than mainland ecosystems (Veitch & Clout 2002). Successful programs of ant suppression have been reported in the literature (Drees 1994). Nevertheless the following factors need to be considered if implementing an ant eradication program.

6.3.1 Failure of treatment:

Most pest management methods work better at one time of the year than another, and there may even be times when they are ineffective because different pest life history stages may be more or less vulnerable to different management methods. The type of baits that are usually employed for ant control are those that kill the colony when toxins are taken into the nest. The toxin levels are deliberately set low so that ant foragers do not die immediately and return to the colony. A bait effectiveness trail could be conducted to test the feasibility of eradication. The south-eastern section (about 5 ha of infestation) of West Island might be a good place to do this. The CSIRO entomological research unit in Darwin has been undertaking research into the ecology and impacts of exotic ants since 1996, and it has much experience in coordinating and implementing eradication programs. A successful eradication program of tropical fire ants in Kakadu National Park has shown no re-infestations 12 months after several colonies were killed (Moloney & Vanderwoude 2002, DEH 2004, Hoffman & O'Connor 2004).

If eradication is the preferred management choice then two key considerations are needed:

- the spread of chemical baits can be more effective when vegetation cover is low and, hence, control in the dry season would be preferred; and
- minimise disturbance to the breeding colonies of seabirds: from previous studies of the phenology of the breeding activity of all the species present at Ashmore ((ANPWS 1989; Milton 1999 a–b; Swann 2001; Curran 2003), July and August appear to be the best time (lowest number of breeding birds across the different species).

Effective planning of the eradication program may avoid many of the risks listed above.

6.3.2 Re-infestation

Procedures and policies should be implemented in order to avoid re-introduction of the invasive species. This paragraph identifies likely invasion pathways of tropical fire ants to Ashmore Reef islands and should be considered in conjunction with whatever management action is taken by the Department of the Environment and Water Resources (formerly Department of the Environment and Heritage).

The major invasion pathways of invasive species to island ecosystems are diverse and influenced strongly by its trade status (UNEP 2003). Table 10 summarises likely invasion pathways of tropical fire ants to Ashmore Reef islands.

Table 10 Most likely pathway of invasion of tropical fire ants to Ashmore Reef

Pathway	Means of introduction
Floating debris	Organisms moving on garbage (e.g. bottles, nets, packaging)
Boats and ships	Organisms attached to interior or exterior structures and equipment released into the environment
Tourism and other human movement	Organisms moved on people (especially shoes) and their property and escape into the environment
Buoys Floats	Organisms attached to structures

As such, operational guidelines on precautions to take while visiting the islands should be taken into consideration to avoid re-introduction. Recommendations to minimise re-introductions are listed below:

- Floating debris: continue with regular inspections and removal of debris that is undertaken by Customs Officers on the three islands.
- Boats and ships: unforseen landings on the islands, or the sinking of derelict Indonesian fishing vessels just offshore, could lead to re-infestations.
- Tourism and other forms of human traffic: if island visits are permitted then it is recommended that quarantine precautions should be taken and enforced (eg washing shoes, carefully inspecting food containers or other material taken on the island).

6.4 Control to a target density

The control or containment of the invasive species to a target density includes some other issues and associated risks. In order to better understand the dynamics that regulate the presence of the tropical fire ant at Ashmore and their effect on the different seabird species, more quantitative data on the breeding success of birds and the interrelations between birds and ants need to be acquired. This would necessarily involve many hours of observations and sampling on each island, necessitating intensive, long-term monitoring programs. The down-side is that greater human disturbance can occur to seabird breeding colonies while conducting field research. Scientific research programs may have short or long-term impacts on seabird populations if they are not implemented carefully (Rodway et al 1996, Carney & Sydeman 1999, Nisbet 2000, Carney & Sydeman 2000, Chatto 2001) and, hence, the right balance needs to be struck. With appropriate precautions, researchers can often reduce their impact and conduct research without decreasing nesting success (Burger & Gochfeld 1993, Nisbet 2000).

On the basis of the experience acquired during this project, below we provide some suggestions about the survey design, and data that need to be acquired if this option will be chosen.

6.4.1 Ant monitoring methods

The results of our investigation shows that mean visual abundance ranks at bait stations are reasonably correlated to paired night-time pitfall data. Although visually ranking abundance at bait stations may be quicker, the pitfall data may be a better index of abundance because it is integrated over a longer period of greater ant activity. Additionally, bait loss would not be an issue.

Counts of tropical fire ant nests may be the most efficient method. Nest counts may be more robust indicators of tropical fire ant population abundance than ant activity data (ie catchability in bait or pitfall traps), which depends on time of day and other environmental variables (eg temperature, humidity, wind etc). Hence, the density of tropical fire ant nests should be relatively constant over short survey intervals, perhaps resulting in a more robust index of population abundance, although it may vary seasonally. Needless to say, the survey of tropical fire ant nests can be refined considerably to be more repeatable if necessary.

6.4.2 Data and methods to survey seabird nesting recruitment for future monitoring

The following data should be collected while surveying seabird nesting recruitment.

Life history

Life history attributes are definitely needed in any future monitoring program (and per grid cell): nest numbers; mean clutch size; hatching success; proportion alive in each age/size cohort up to fledgling; and number dead birds in each size/age class again. As mentioned above, a major limitation and issue is disturbance caused by intensive research activity. The possibility to use remote monitors (eg environmental data loggers, telemetry, videography etc) instead of conducting direct sampling, might be an alternative option. Nevertheless, the life table approach to estimating key population parameters (ie. mortality rate, survival rate, fecundity rate – all at different levels of exposure to tropical fire ants) is an absolute must in future surveys.

Causes of natural mortality

There is a need to differentiate, and, if possible quantify, natural causes of mortality from mortality caused by tropical fire ant predation. Natural causes of mortality include: interspecific and intraspecific predation, diseases, food, weather and competition for space/habitat (eg the % vegetation cover relationship).

Behaviour

There is a need to assess if disturbance by tropical fire ants to parental care is an issue (ie an indirect mortality effect).

Predation behaviour

There is a need to estimate the kill rate by tropical fire ants (functional response) – ie numbers killed as a function of chick density.

A tight, well-focused study design is needed, in order to enable constant assessment of management actions and to refine the damage-pest density model (ie test all the underlying assumptions).

In order to establish the acceptable level of density it will be necessary to establish indicators of management success (ie. goals, what to monitor). Although the socially acceptable damage level here is zero deaths to chicks from ants, the focus should be on the acceptable damage level, not the pest density.

Needless to say, the effectiveness of mitigation measures, or eradication should be constantly monitored in order to ensure that re-introduction is not occurring or that densities are maintained at the acceptable level.

6.5 No action

The resolution VII.10 of the Ramsar Convention provides the definition for 'Ecological character' and 'Change in Ecological character'. Contracting Parties have to ensure when managing Ramsar-listed sites that the Ecological character of wetlands is maintained through management and wise use. On the basis of the results of our risk-assessment, failure to adequately prevent and minimise the impacts of tropical fire ants may seriously affect the 'Ecological Character' of the Ashmore Reef Ramsar site. As such the 'no action' option might include too high a risk of having to face a situation that becomes, over a period of time, more critical than at present (ie explosion of population of ants with high costs to eradicate or control the invasive species).

6.6 Conclusions

Although we do not have direct evidence (observational and/or experimental data) that the tropical fire ants were directly responsible for a percentage of the recorded deaths of Common Noddies, the statistical correlations that we obtained during our survey concord with known theory and impacts elsewhere. As such, and for the many reasons listed in Section 6.1, the presence of tropical fire ants at Ashmore Reef continue to be a matter of serious concern.

We have discussed issues and associated risks related to different management choices (eradication vs control). Disturbance to the breeding colonies is the major limitation to a control program. An eradication program may involve few visits to the islands and, in contrast, a control program would involve several visits per year ad infinitum. On the other side financial constraints and risk of re-infestation are the limitation of an eradication program.

We therefore recommend that a cost/benefits analysis be undertaken before opting for one or the other management action, and on the basis of the information collected, seek further advice from pest-management experts (eg CSIRO – Darwin).

Pest-management experts can provide valuable advice whether eradication will have a high probability of being successful at Ashmore, and economically more advantageous than a control program. If this is the case, providing that Ashmore Reef is a Ramsar site and that its terrestrial ecosystems support unique ecological values, eradication might remain the most desirable management action.

Finally it is important to underline that other threats, such as invasive plants, are potentially impacting the terrestrial ecosystem of the island, and have a potential detrimental effect on the habitat available to ground nesting birds at Ashmore. An integrated assessment that considers the effects and impacts of different threats would provide useful guidelines on how to set priorities for management actions.