Wetlands for the Future

Editors

A.J. McComb and J.A. Davis

Gleneagles Publishing
Adelaide

The impacts of runnelling on saltmarsh vegetation and substrate

JANE A. LATCHFORD

Institute for Environmental Science, Murdoch University, Murdoch 6150, Western Australia

Abstract

The environmental impacts of runnelling (a mosquito control technique) were examined on the low marsh vegetation of saltmarshes within the Peel-Harvey estuary, WA. Above-ground biomass of *Sarcocornia quinqueflora* was harvested from two sampling zones (one 0 m and one 10 m from saltmarsh pans) at the three study locations, while pore water and soil parameters were monitored. Large variations in *Sarcocornia quinqueflora* biomass occurred over the two years of study, which appeared to result from varying environmental conditions. There were altered salinity patterns during spring and winter at one site, however these changes were small in comparison to the naturally occurring seasonal changes. The results indicate that runnelling does not significantly alter the abundance and productivity of *Sarcocornia quinqueflora*.

Introduction

For decades mosquito control has been practised in countries around the world. In southwestern Australia mosquito control is practised to reduce the incidence of polyarthritis, a disease instigated by Ross River and Barmah Forest virus.

Polyarthritis is a very debilitating disease, the symptoms of which are a fever, arthritic symptoms in several joints, a rash and lethargy. The arthritic syndrome may persist for several months or years and can result in significant economic impact through reduced efficiency of the workforce. Ross River virus, the mosquito-borne virus which causes this disease is the most widespread and important of the Australian arboviruses, which occurs every year throughout Australia (Liehne, 1991; Russell, 1993).

Prior to the 1990s the most common method of mosquito control was application of an organophosphate insecticide called Temephos or Abate to the larvae. This is a systemic poison which produces repeated nerve firing, resulting in paralysis and death (Rao, Suamy and Yamin, 1992). It is reported to have extremely low mammalian and avian toxicity and to have little effect on fish. This impact is minimised by a very short residual life (Lores *et al.*, 1985; Moreau, 1988). However, the persistence of Abate in water appears to range from two hours to seven days depending upon habitat and environmental conditions (Chapman, 1993). Doubts have also been raised about the supposed low toxicity of Abate on avian fauna, following the deaths of birds in Forrestdale Lake, Western Australia and in the Murray River and Riverina rice growing areas of New South Wales (Keeling, 1984).

Further doubts regarding the safety of Temephos have been raised concerning its effects on non-target macroinvertebrate populations (Ruber and La France, 1983; Davis, Wienecke and Balla, 1987; Fortin, Maire and Le Clair, 1987). Continued reliance upon one form of mosquito control is also viewed as unadvisable, because of the ability of mosquitoes to develop chemical resistance (Chapman, 1993; Russell, 1993). Thus other forms of mosquito control such as insect growth regulators, bacterial insecticides and source reduction are being explored by Health authorities in Australia. This paper presents results from a study into source reduction.

Source reduction is the physical modification of larval breeding areas to reduce or eliminate breeding in carefully selected areas. The ultimate objective of mosquito source reduction is to install low-cost, low-maintenance physical modifications that provide effective control of saltmarsh mosquitoes while having a minimal environmental impact (Dale and Hulsman, 1990; Russell, 1993).

The form of source reduction explored was open-water marsh management. The principle is to increase water access to the marsh. In New South Wales and Queensland a form of open-water marsh management called 'runnelling' has been developed with great success, and a decision was taken to explore this technique in greater detail in the marshes of southwestern Australia (Dale and Hulsman, 1990).

Runnels are very shallow spoon-shaped channels which connect pans in saltmarshes to the open waters of estuaries. The width is three times greater than the depth, and they follow natural drainage lines along a very low gradient. The aim of runnelling is to increase tidal flushing and flush of surface water accumulating from rainfall. The depth of runnels and pans is adjusted such that water is drained from the lowest pan on an ebb tide (Dale, Hulsman and Kay, 1986; Hulsman, Dale and Kay, 1989; Dale and Hulsman, 1990).

The target mosquitoes are saltmarsh species which lay their eggs on damp mud, and hatch when inundated by the tide or rain. In summer the adult mosquitoes can develop within five days. In order to break this lifecycle water needs to drain from of the saltmarsh pans before the adults emerge from the pupal case. Thus water must drain from the pan to the estuary before the fifth day.

Mosquito breeding is discouraged by this reduction in water stagnation time, increasing access of estuarine fish to larval mosquitoes, and by flushing larvae off the marsh into the more hazardous open-water environment. It also appears to affect oviposition site characteristics, making them less attractive to gravid adults (Easton, 1986; Hulsman and Dale, 1988).

An area suitable for runnelling is where a natural channel already exists and where there is sufficient tidal range to ensure adequate flushing. The modification should make use of existing pans and depressions to channel the flow of water. When creating runnels it is preferable to use drier periods of the year when less mechanical damage is likely to occur on the firmer substrate. Spoil from the runnels can be used to fill breeding depressions not designated for connection to runnels, or spread thinly over the marsh (Dale, 1991).

As well as providing a habitat for mosquitoes to breed saltmarshes are productive and important in supporting the estuarine ecosystems. It was therefore necessary to examine the environmental impacts of runnelling on the saltmarsh, as well as its effectiveness in controlling mosquitoes. In order to detect ecological effects, the hydrology, vegetation, aquatic fauna and flora and avian fauna were examined. This paper discuss how effective runnelling was in controlling mosquitoes and its impact upon hydrology and saltmarsh vegetation.

Methods

Study area

The area chosen for the study was the Peel-Harvey Estuary 75 km south of Perth, in Western Australia (Figure 1). The town of Mandurah is situated on this estuary and is an important commercial fishing and tourist centre. Studies have shown that Ross River virus is endemic in the Peel-Harvey region, and during summer 1994 a small outbreak of Barmah Forest virus occurred there (Lindsay *et al.*, 1994).

Within this area three sites were chosen and are shown in Figure 1. The sites were of different size and contained different numbers of pans. Site 1, the largest of the three, was modified with runnels before the study began. Sites 2 and 3, of comparable area, were modified after a year, to enable a pre and post modification comparison. All three sites had control (unrunnelled) pans. The sites ranged from saline (Site 1 and 2, which are in the Peel Inlet) to relatively fresh (Site 3 on the Serpentine River flood plain).

Mosquito study

The two major coastal and estuarine pest species in the south-west of Western Australia are *Aedes camptorhynchus* and *Aedes vigilax*. *Aedes camptorhynchus* is present all year, while *Aedes vigilax* is prevalent in summer. *Aedes camptorhynchus* is a known vector of Ross River virus in southwestern Australia, while *Aedes vigilax* is a proven vector in the north of the state (Liehne, 1991). Barmah Forest virus has been isolated from *Ae camptorhynchus* on numerous occasions in the Peel and Busselton areas of Western Australia (Lindsay *et al.*, 1994). To assess the effectiveness of runnelling in controlling these species, larval mosquitoes were monitored fortnightly or more frequently during occasions of high tides and/or rain, at the three sites from April 1991 to April 1993. At least ten random scoops with a soup ladle (150 mL) were taken per pan or runnel and larvae counted. These values were then adjusted to a standardised volume of pan water to allow comparisons over time. The data was plotted with CA-Cricket Graph III (Computer Associates) and simple one-way ANOVAs performed using Statistica (Statsoft) with treatment (runnelled or non-runnelled) treated as a fixed factor.

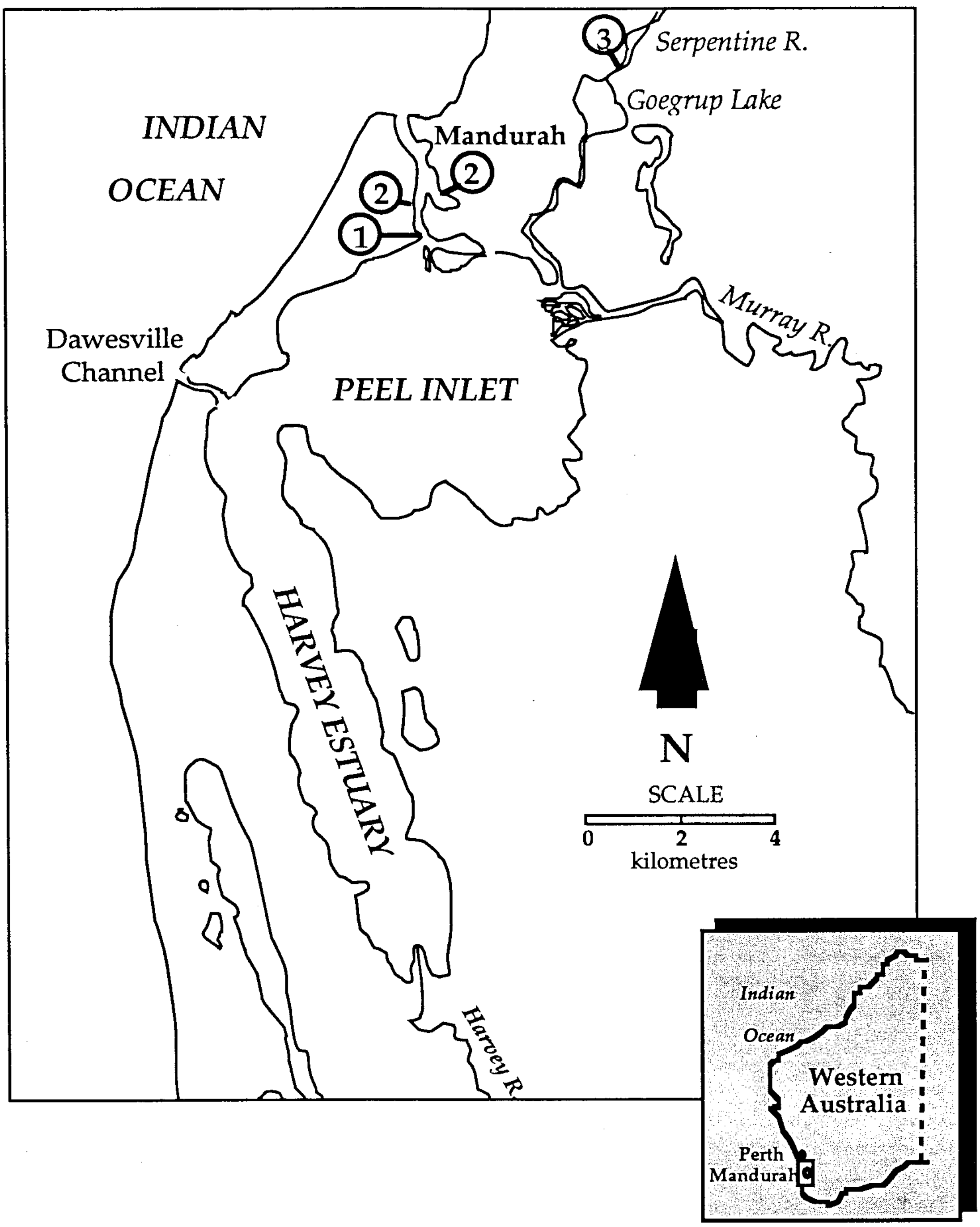

Figure 1. The Peel-Harvey Estuary, with the location of the three study sites indicated by closed circles.

Environmental impacts

Transects of standpipes were installed at each pan, extending ten meters outwards from the centre. Monthly measurements were taken of water depth, salinity and pH over two years.

In temperate Western Australia *Sarcocornia quinqueflora* is the dominant plant of the low marsh. As most mosquito breeding pools are within the lower marsh, it was important to examine the impact of runnelling on *Sarcocornia.* This was done by harvesting above-ground biomass of *Sarcocornia* at the beginning and end of the growing season in two vegetation zones at each transect. The zones were 0–2 m and 8–10 m from the saltmarsh pan. Soil and pore water samples were also taken from these areas. The data was plotted with CA-Cricket Graph III (Computer Associates, 1992) and repeated measures ANOVAs performed using Statistica (Statsoft, 1992).

Results and discussion

Mosquito study

There were statistically-significant reductions in larval abundances in the runnelled pans at all sites. An example of this reduction was seen at site 3 (Figure 2). The abundance of larval mosquitoes was effectively reduced during most seasons, as is seen for example at site 2 (Figure 3). The only time larval mosquito numbers were not lower than the control after runnelling was in winter, when water levels remained very high in the estuary, preventing flushing from the marsh.

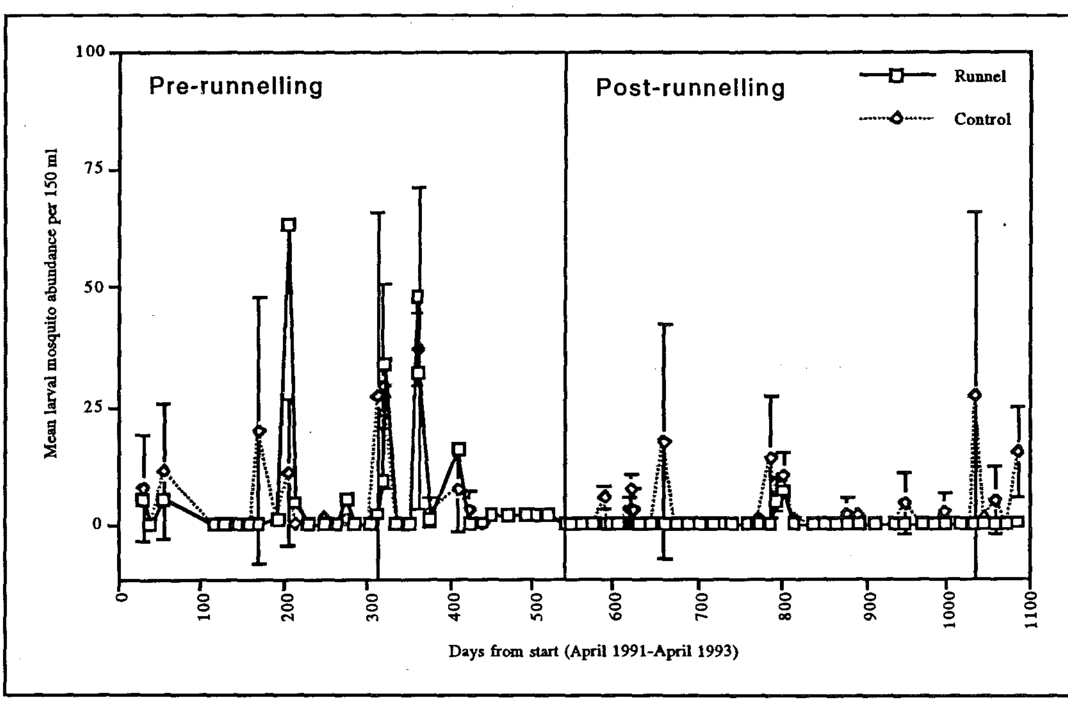

Figure 2. Larval mosquito abundance (mean ± SE) at Site 3 before and after runnelling.

Ross River activity varies from year to year, but as a general rule more isolations are made during the warmer months. Thus if abundant adult mosquitoes are present, virus activity is more prevalent in late spring, summer and early autumn. It was concluded that runnels effectively reduce larval mosquito populations during periods of high virus activity.

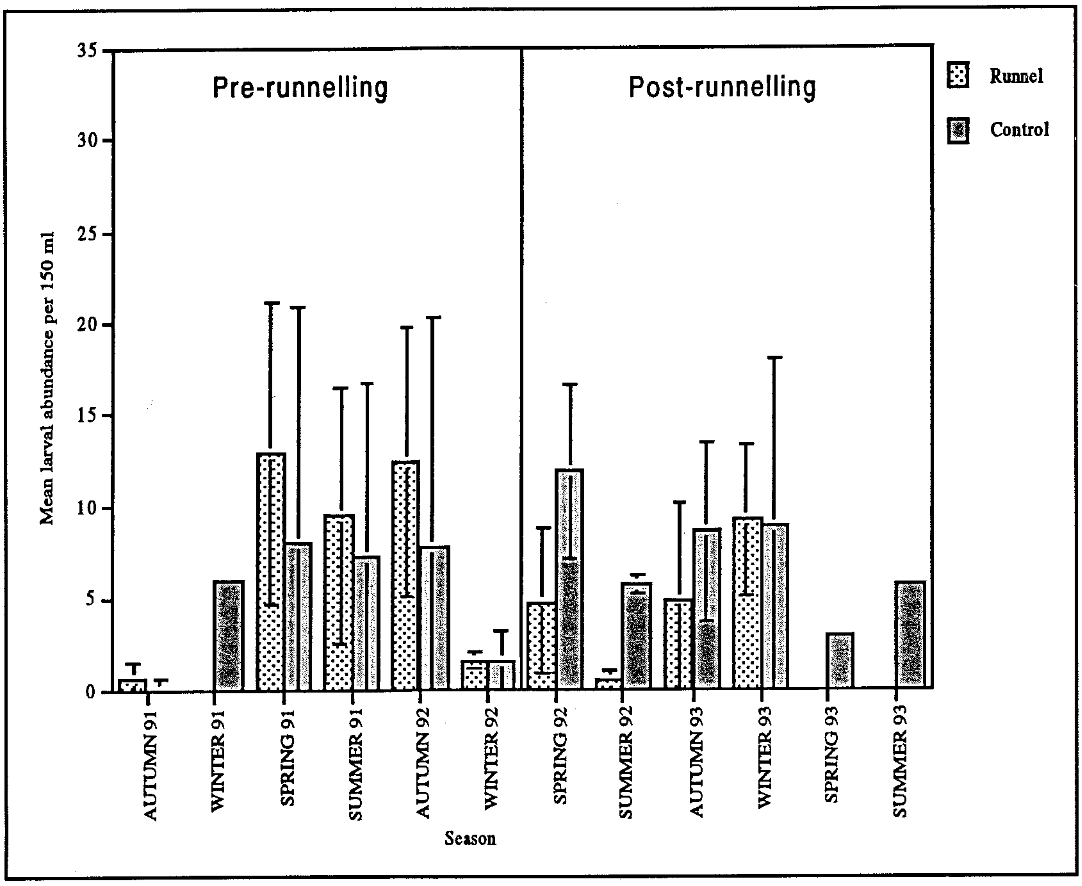

Figure 3. Mean seasonal larval abundance (± SE) at Site 2 before and after runnelling.

Environmental impacts

The hydrological impacts of runnelling appear to be minimal. Altered salinity concentrations during winter and spring were recorded for site 2 (Figure 4). However these changes were small in comparison to the naturally occurring seasonal changes. Acidification of the surface or groundwater did not occur and there was no channel retrogression. It was concluded that runnelling did not significantly alter hydrological patterns in the saltmarshes.

There were no significant differences in plant biomass, soil properties and nutrient concentrations between runnelled and control pans at any of the sites. The data suggest that impacts on *Sarcocornia quinqueflora* saltmarshes resulting from runnelling were undetectable over the length of this study.

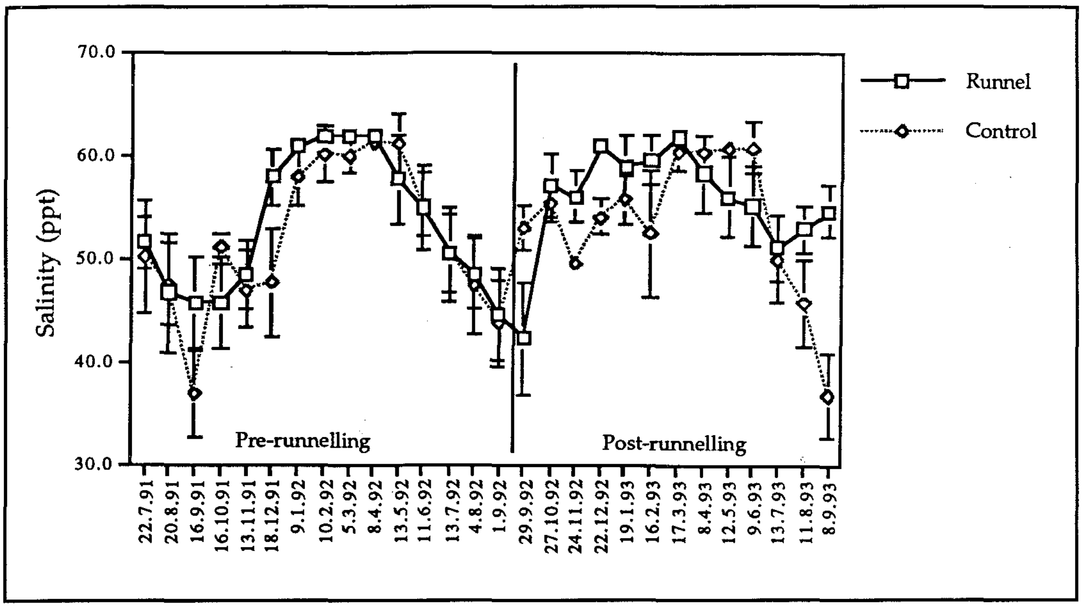

Figure 4. Mean salinity (± SE) at Site 2 before and after runnelling.

Conclusion

This study has demonstrated that runnelling leads to reduced numbers of larval mosquitoes in periods when Ross River virus activity is high. The runnels operated effectively shortly after construction, through a combination of flushing, increased predation and reduced oviposition. In most cases larval mosquito abundances are very low, but occasional chemical control may be needed. This reduction in the use of chemical control will benefit both the saltmarsh ecosystem and the community. The one-off cost of implementing runnelling will be paid for by the reduced expenditure on chemical control costs within several years (Dale *et al.*, 1989). If designed well, there is little need for maintenance of the runnels.

There were minimal hydrological impacts attributable to runnelling and it did not significantly alter the abundance and productivity of *Sarcocornia quinqueflora.* From the data presented in this paper and other results from the study, it is concluded that runnelling is an effective and environmental appropriate method of mosquito control, which should be considered as an alternative where the productivity of the saltmarsh is important ecologically.

Acknowledgments

This study was funded by the Health Department of Western Australia. The author would also like to thank Verity Klemm and Edwin Chester from the Waterways Commission, Nick Long from the Mandurah City Council and staff from Murdoch University.

References

Chapman, H.F., 1993. The impact of Abate (temephos) on nontarget organisms: a literature review. Prepared for Maroochy Shire Council, Queensland, 31 pp.

Dale, P.E.R., Hulsman, K. and Kay, B., 1986. Development of saltmarsh mosquito management programmes in Queensland. Arbovirus Res. Aust. 4: 185–189.

Dale, P.E.R. and Hulsman, K., 1990. A critical review of salt marsh management methods for mosquito control. Reviews in Aquatic Sciences 3(2/3): 281–311.

Dale, P.E.R., 1991. Guidelines for habitat management for mosquito control in south east Queensland. Unpub discussion paper Jan. 1991, Griffith Uni/CLAG/QIMR, 32 pp.

Dale, P.E.R., Hulsman, K., Easton, C.S. and Kay, B.H., 1989. Recent advances in habitat modifications for saltmarsh mosquito control—south east Queensland and northern NSW. 6th Arbovirus Symposium pap.

Davis, J., Wienecke, B. and Balla, S., 1987. A preliminary investigation of the impact of the pesticide Abate on the non-target invertebrate fauna of Forrestdale Lake. School of Environmental and Life Sciences, Murdoch University. Report for the Dept of C.A.L.M.

Easton, C. S., 1986. Saltmarsh mosquito reduction in Tweed Shire using tidal recirculation channels. Environmental Health Review Feb., 5–9.

Fortin, C., Maire, A. and Le Clair, R., 1987. The residual effect of temephos (Abate 4-E) on non-target communities. J. Am. Mos. Con. Ass. 3(2): 282–288.

Hulsman, K. and Dale, P.E.R., 1988. Management of a sub-tropical coastal salt-tropical coastal salt-marsh for mosquito control. Proc. Ecol. Soc. Aust. 15: 227–288.

Hulsman, K., Dale, P.E.R. and Kay, B.H., 1989. The runnelling method of habitat modification: an environment focused tool for saltmarsh mosquito management. J. Am. Mosq. Control Assoc. 5(2): 226–234.

Keeling, S., 1984. Pesticide spraying, threat to birdlife. Environment W.A. 6: 6–8.

Liehne, P.F.S., 1991. An atlas of the mosquitoes of Western Australia. Health Department of Western Australia, Perth, 284 pp.

Lindsay, M.D., Smith, D.W., Johansen, C.A. and Mackenzie, J.S., 1994. Barmah Forrest virus disease in Western Australia. Western Australian Notifiable Diseases Bulletin 4(4): 1–4.

Lores, E. M., Moore, J.C., Moody, P., Clarke, J., Forester, J. and Knight, J., 1985. Temephos residues in stagnant ponds after mosquito larvicide applications by helicopter. Bull. Environ. Contan. Toxicol. 35: 308–313.

Moreau, C.M., 1988. Data sheet on the impact of pesticides on non-target organisms. WHO/VBC/88.955. World Health Organisation, Geneva.

Rao, J.V., Suamy, A.N. and Yamin, S., 1992. Rat brain acetylcholinesterase response to monocrotophos and Abate. Bull. Environ. Contam. Toxicol. 48(6):850–856.

Ruber, E. and La France, K., 1983. Effects of Temephos on the respiratory rate of the saltmarsh amphipod, *Gammarus mucronatus*. Bull. Environ. Contam. Toxicol. 31: 148–151.

Russell, R.C., 1993. Mosquitoes and mosquito-borne disease in southeastern Australia: a guide to the biology, relation to disease, surveillance, control and the identification of mosquitoes in southeastern Australia. Dept of Medical Entomology, Westmead Hospital, Westmead, NSW, 476 pp.