The Ecology of Exotic Animals and Plants

SOME AUSTRALIAN CASE HISTORIES

edited by

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John Wiley & Sons
Brisbane • New York • Chichester • Toronto • Singapore

First published 1986 by
JOHN WILEY & SONS
65 Park Road, Milton, Qld 4064
140A Victoria Road, Gladesville, N.S.W. 2111
90 Ormond Road, Elwood, Vic. 3184
4 Kirk Street, Grey Lynn, Auckland 2, N.Z.

Typeset in 11/13 pt Paladium

Printed in Australia by
Watson Ferguson & Co., Brisbane

National Library of Australia
Cataloguing-in-Publication data

The Ecology of exotic animals and plants.

Bibliography.
Includes index.
ISBN 0 471 33418 9.

1. Ecology – Australia. 2. Animal introduction – Australia. 3. Plant introduction – Australia. 4. Pest introduction – Australia. 5. Acclimatisation – Australia. 6. Acclimatisation (Plants) – Australia. I. Kitching, R. L. (Roger L.), 1945-

574.5'0994

Copy edited by Rosanne Fitzgibbon

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Preface

The wild animals and plants most Australians see on a day-to-day basis – the rabbits, foxes, cabbage butterflies and garden weeds, for instance – are not in fact native to these shores at all. They are exotics, having been brought to Australia either accidentally or on purpose by Europeans. Some have little impact on our lives or those of the native flora and fauna, but many have responded to their release into a 'land of plenty' by increasing in numbers explosively and spreading to occupy large tracts of the continent. Not only have they increased in numbers but they have also inflicted and continued to inflict damage on our crops, stock and native ecosystems, costing untold millions of dollars. Principally for this reason, they have often been the subject for detailed ecological research by the universities, state departments of agriculture, primary industry or lands, and the C.S.I.R.O. This research has led to sometimes dramatic solutions to the problems created by these invaders although, in other cases, they have proved intractable to control. In all cases the work has led to great insights into how these elements of our landscape operate, what their impacts are, and how they compare with the same species elsewhere and with native organisms here.

This work draws together some of the best of this work so that it will be readily accessible to students at all levels. In addition it provides a ready reference for the research worker entering upon the study of these or associated organisms and a fascinating account of some of our most familiar organisms for the interested lay person.

The work compliments an earlier compendium on selected pest species and is the second in a projected series of three. The series is designed to make generally available the results of the large amount of excellent Australian ecological research carried out over the last two decades, much of which never appears in Northern Hemisphere-orientated textbooks. The series will be completed by a compendium on the ecology of selected native species of animals and plants.

As editor it is my pleasure to thank each of the contributing authors for their prompt responses to my requests for manuscripts, revisions and proofs and for their patience in enduring the inevitably long gestation period of a work of this sort. I thank Ms Theresa Johnston and her staff in the School of Australian Environmental Studies at Griffith University for secretarial and typing assistance and Professor R. E. Jones for her general advice on the work.

R. L. Kitching, Armidale, July 1986

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Chapter 1
Exotics in Australia and elsewhere

R. L. Kitching

Introduction

In 1981, together with Professor R. E. Jones, I compiled a book on the ecology of pests (Kitching & Jones 1981). The purpose of that work was to present a series of Australian case histories, each chapter dealing with one organism or a small group of organisms, the biology and ecology of which had been well studied in this country. The range of organisms spanned species from crown-of-thorns starfish to kangaroos, from bushflies to skeleton weed. The chapters collated more or less all that was known about each of the organisms at that time, and were presented by authorities in the field to provide students and others with an information base which could be used *inter alia* to leaven the northern hemisphere bias of their usual texts and sources.

One volume could only include a few such case histories and, after *The Ecology of Pests* had enjoyed some currency, I set about assembling a second set of accounts. Rather than simply doing *Pests II* I decided to change the focus slightly to encompass a different, if overlapping, set of organisms, including species on which substantial amounts of good research are being done. In this volume, then, are thirteen accounts of animals or plants which were not present in Australia before the time of European settlement. They were introduced subsequently by man, either deliberately or accidentally. Some, such as the rice weevils, probably came with the First Fleet; others are much more recent in origin. As with *The Ecology of Pests*, significant omissions are inevitable in an enterprise of this sort. Lack of space, time and willing authors led to key omissions, and the usual accidents of personal knowledge and location led to the final choice. Some species which appear neither in this work nor in *Pests* cry out for attention. Rabbit and cattle tick, wild pig and armyworm, lantana and groundsel bush, prickly pear and camphor laurel are just a few that come to mind. Taxonomic spread, too, is something editors can only hope to even out. The ubiquitous insects received the lion's share of attention in *The Ecology of Pests*; here, the vertebrates seem to have taken line honours although I believe the spread to be more even this time.

Lastly, and following a criticism of the earlier book (Ives 1982), I have concluded this volume with a short chapter that looks for (and occasionally finds) common ground among the organisms described here. In addition, I have

attempted to relate the biology and ecology of the species concerned to some recent theoretical ideas in population and community ecology.

Why exotics?

As a category, exotic animals and plants have attracted substantial natural historical, ecological and even historical attention (e.g. Rolls 1969; Salisbury 1964; Druett 1983). Learned symposia have been devoted to them in Australia and elsewhere (Anderson 1979; Harper 1960) and whole areas of ecological thinking have been aided by their study (Elton 1958; MacArthur & Wilson 1967). So why do exotic species attract this level of notice? I believe there are three reasons of importance.

Firstly, there is a purely human aspect to this preoccupation. In other parts of the world exotics attract attention because they are a visible contrast to the more mundane indigenous fauna. Muntjac deer, for instance, have received more than their fair share of research in the United Kingdom probably for this reason. Although this 'novelty' aspect may be a factor in Australia (as evidenced for instance by the very detailed records of the first appearance of various species like the monarch butterfly – see chapter 9), a much stronger force is at work. European man, himself a recent exotic on the Australian continent, perceived the native biota as strange, sometimes even sinister, often unimportant. He set about changing this flora and fauna by deliberate introduction – for hunting, ornament or some more subtle reason such as wishing to establish in Australia a full complement of biblical, English or Shakespearian mammals or birds! Such exotics sometimes thrived, usually in the regions in and around men's dwellings and farmlands. They remained familiar to man and at least intermittently in public view.

Of course many exotics, whether deliberately or accidentally introduced, *demand* scientific and public attention due to their immediate impact on man, his crops and domestic animals. Examples are legion and most of the case histories discussed in this volume fall into this category. The devastation wrought by exotics such as the rabbit (see, e.g., Rolls 1969) or the prickly pear (Dodd 1940) reached calamitous proportions and the scientific solutions to the problems they presented were both eagerly awaited and widely acclaimed. Surprisingly not all species have received attention in proportion to their impact and some remain relatively poorly known. Cane toads (chapter 3), feral cats, lantana and rats come to mind. Other 'exotics' have avoided attention by their supposedly innocuous, even beneficial nature. Eastern Australian species introduced to the west, such as the kookaburra and various *Acacias* used in mine reclamation, are cases in point.

Lastly exotics have been studied for the opportunities they present for the study of fundamental ecological questions. Ecologists are concerned to try to account for the occurrence and abundance of animals and plants in space and time. We do this by invoking the operation of various processes such as invasion, succession, competition, predation and so on. In many cases involving indigenous species we observe a situation which has come to some state of balance (even though

this may be a complex one – see, e.g., Clark & Dallwitz 1975; Schaffer & Kot 1985) and we must infer the processes which led to such states in the past. To test our inferences we may choose to manipulate the natural systems by experimentation, but such exercises are necessarily on a small scale. With exotics, however, massive unintentional experiments are provided for us, the outcomes of which are not yet complete in many cases. These give us the opportunity to predict limits of distribution, impacts on the receiving community, population fluctuations, short-term evolutionary changes and the like, which we can then evaluate as the invasion process unfolds. Few ecologists would advocate large-scale, uncontrolled introductions now (although biological control agents and continued introductions of freshwater fish may provide instructive exceptions). However we can and should take advantage of the special opportunities presented by the accidental arrival and spread of exotics.

Exotics in Australia – how many?

Semi-popular treatises such as that of Rolls (1969) may give the impression that Australia is particularly hard hit by exotic species in its flora and fauna. Certainly there are exotic elements in most groups other than the special Australasian endemics like marsupials and many sclerophyllous plants. Table 1.1 collates information about the numbers of exotics in a number of taxa, and also contains comparative data from New Zealand, Great Britain and North America as available, collated in most instances from standard floras and field guides. In fact, using the tabulated data, Australia has no more, and in many cases fewer, exotics in

Table 1.1: Numbers and proportions of exotic species for selected elements of the flora and fauna of Australia, with comparative data for New Zealand, Great Britain and the United States or parts thereof, as available.

Group	Australia			New Zealand			Great Britain			United States		
	Total	Exotics	%	Total	Exotics	%	Total	Exotics	%	Total	Exotics	%
Terrestrial mammals	247	20	8	36	33	92	56	12	22	353	7	2
Non-marine birds	605	25	4	94	33	35	265	37	14	562	25	5
Non-marine reptiles	118	1	1	37	1	3	8	2	25	289[1]	11[1]	4[1]
Amphibians	150	1	0.7	5	2	40	8	2	25	154[1]	2[1]	1.3[1]
Freshwater fish	149	19	13	47	12	26	57	9	16	not available		
Terrestrial molluscs	1000[2]	50[2]	5[2]	386	13	3.3	81	5	6	not available		
Butterflies	382	2	0.5	17	2	12	65	2	3	670	1	0.2
Solanaceae	198	66	33	13	10	77	13	9	69	42[3]	20[3]	48[3]
Chenopodiaceae	302	15	5	19	9	47	42	12	29	42[3]	18[3]	43[3]
Brassicaceae	160	71	44	61	40	66	135	72	53	131[3]	60[3]	46[3]

[1]Based on Conant (1975) for Eastern and Central North America.
[2]Estimates provided by Dr J. Stanisic, Queensland Museum.
[3]Based on Gleason (1952) for the north-eastern United States and Canada.

its biota than the other regions selected for attention here. Certainly, in comparison with New Zealand we are relatively free of such elements. Of course, New Zealand is particularly vulnerable to invasion, being an oceanic island with a depauperate indigenous fauna, particularly among the vertebrates. The situation there, as in Australia, has been exacerbated as European man has introduced his agricultural practices and all they imply.

It can be argued that the table is unrepresentative and, inasmuch as it represents but a small selection of the flora and fauna, this is true. Had groups such as aphids, noctuid moths or composites been included, a much higher proportion of exotic species might have been found. However I do not believe that the comparative data would have led to different conclusions about Australia's 'susceptibility' to exotic invasion. Of course here as elsewhere exotics achieve a prominence out of all proportion to their species diversity. There are two principal reasons for this in Australia. Firstly, in biological terms, our exotics are newcomers and often are still in the phase of having large impacts on the environment around them. Rabbits, for example, are exotics both here and in Britain. Here they were introduced by the early settlers less than 200 years ago; in Britain they accompanied the Roman occupation almost 2000 years ago. There were no ecologists around to record the impact of the species on a previously rabbitless Britain, but we infer it to have been substantial. Indeed so dramatic was this impact that, when rabbit numbers were drastically reduced by myxoma virus in the 1950s and 1960s, there was protest at the deterioration and eventual loss of the short grasslands of southern England with their unique flora and fauna. Various rare herbaceous plants have virtually disappeared, as has the large blue butterfly which relied upon a particular species of ant for the completion of its life cycle – the ant required the added insolation of short cropped turf (Thomas 1980) and the rabbits' decline has resulted in the local extinction of the species. In Australia, in contrast, the rabbit was still spreading up to the release of myxoma virus in 1950 and its ecological impact before and after the event has been fairly well documented. So we may conclude that the perceived impact of an exotic species on a natural community reflects both the time since introduction *and* the particular temporal 'window' through which we view the situation. Already in Australia there are signs that the surrounding flora and fauna are adapting to the presence of certain exotics which may ultimately establish natural checks on their spread (see, e.g., the case of the cane toad described in chapter 3). Eventually this must be true of all exotics – the species that make up the community around them will co-evolve with the species itself until a new integration is established. At this point presumably the 'new' species is no more 'exotic' than say the indigenous rodents of Australia now seem (see also my account in Kitching 1986).

Secondly, and not unrelated to their recent arrival, exotics in Australia achieve a prominence by providing far more than their fair share of our pests and weeds. Such terms can only be defined loosely, of course, but I note by way of example that of the eleven case histories discussed in *The Ecology of Pests* seven were of exotics: the ratio is six of eight if we consider only insects. Similarly, Lamp and

Collet's (1976) work covers 283 species of which 203 or 72 per cent are of exotic origin.

So, although overall a relatively small proportion of our biota, the exotics have an enormous impact, both economic and aesthetic, which affects every one of us directly and indirectly. Accordingly the justification and need for the chapters that follow is well-founded, reflecting, as did *The Ecology of Pests*, the large amount of first-class work done by Australian ecologists which, arguably at least, receives less than its fair share of attention in the wider literature. There remains much excellent work on the ecology of the indigenous animals and plants and this promises well for a third compendium in this series!

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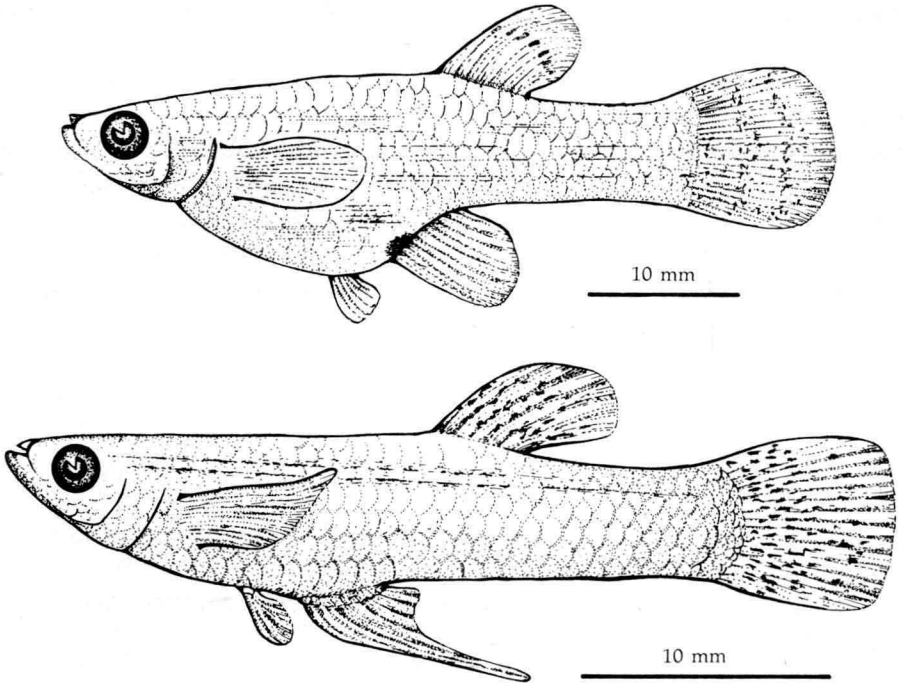

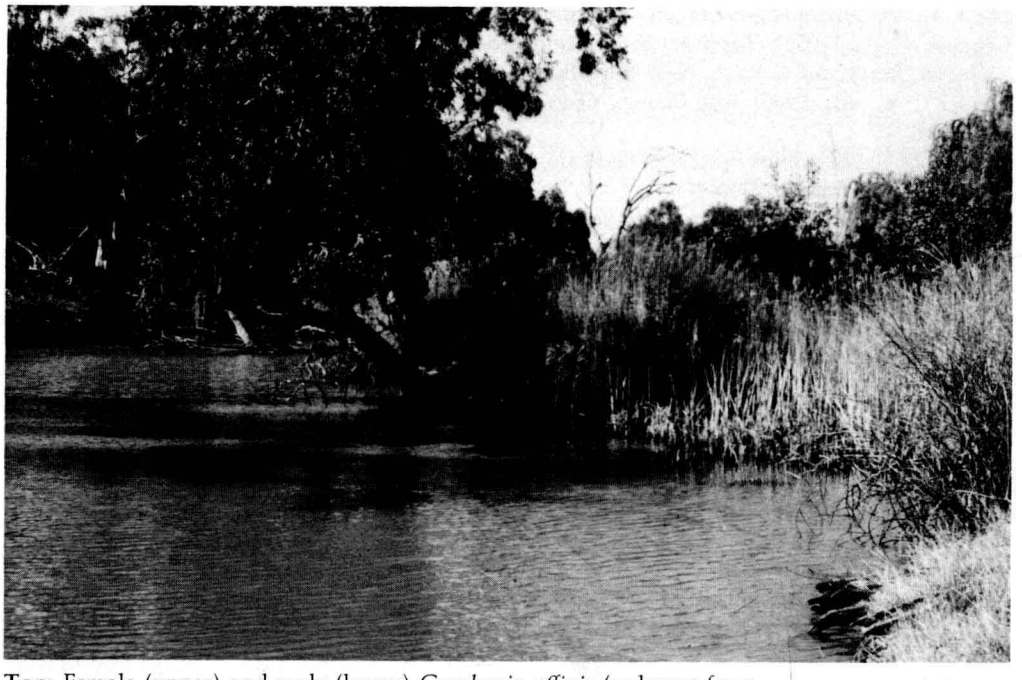

Top: Female (upper) and male (lower) *Gambusia affinis* (redrawn from McDowall 1980, by Ruth Altman); **Bottom:** A typical mosquitofish habitat.

Chapter 2
The mosquitofish — a valuable mosquito-control agent or a pest?

L. N. Lloyd, A. H. Arthington and D. A. Milton

Introduction

The mosquitofish, *Gambusia affinis* (Baird & Girard), is a small, live-bearing fish native to central America that has been distributed worldwide as a mosquito-control agent. It is probably the most widely distributed freshwater fish in the world (Krumholz 1948), although rainbow trout, largemouth bass, common carp, grass carp and the Mozambique tilapia are close rivals (Moyle & Cech 1982). *G. affinis* has been established in the wild in Australia since 1925, but has only recently attracted scientific study (see Trendall 1982; Arthington et al. 1983; Arthington et al. 1986; Arthington & Mitchell 1986; Milton & Arthington 1983). This chapter presents a selective review of the world literature on the biology and ecology of *G. affinis*, placing the limited data from Australia in perspective. We evaluate two related questions: is the mosquitofish of value in mosquito control, and is it having an adverse impact on aquatic environments and native fish populations?

Taxonomy

G. affinis belongs to the family Poeciliidae, order Cyprinodontiformes (Rosen & Bailey 1963). The family consists of various live-bearing species from tropical and subtropical regions of the Americas.

The genus *Gambusia* comprises about thirty species, many of which are rare and restricted in distribution (Rivas 1963). *G. affinis*, however, is widely distributed throughout the southern United States and is split into two subspecies, *G. a. affinis*, the western form, and *G. a. holbrooki*, the eastern form. Mosquitofish are small, translucent grey with a bluish sheen on the sides, and have a silvery belly. The fins are colourless with transverse rows of black pigment spots (Sterba 1962), and in males the anal fin is modified to form a long, thin, intromittent organ, the gonopodium (Peden 1972). The body is slightly compressed, with a large and