Examples of good and bad writing in Ecology journal articles

CALM Scientific Writing Workshop
June 1998

Lively writing style

A first step in understanding the long term evolutionary consequences of these conflicting forces can be achieved by examining the effects of systemic pathogens on host growth, fecundity and competitive ability. To date virtually all studies that take such an ecological approach have focused on perennial, dicotyledonous plants. In these, the consequences of infection have been variable. Initial studies of the interaction between *Ustilago violacea* and *Silene alba* failed to detect any significant difference in the growth and survival of healthy and infected plants (Alexander & Antonovics 1988). More recently though, field work on the same system has shown that infected plants suffer greater mortality than healthy ones during hard winters (Thrall & Jarosz 1994). For other associations such as *Puccinia punctiformis* infecting *Cirsium arvense*, the impact of rust infection depends on factors such as site characteristics (Frantzen 1994). In contrast, increased vigour of infected plants has been observed in other systems such as *Pulsatilla pratensis* infected by *Puccinia pulsatillae* (Wennström & Ericson 1991). However, in none of these examples has it been possible to dissect out the effect of the disease on the host at different stages in the life cycle.

Systemic smut diseases are also common as pathogens of grass species. These interactions have major advantages as experimental tools as the hosts are frequently annual or very short-lived perennials and have a wide range of different growth forms that can be used to increase our understanding of the interplay of host growth-form and systemic pathogen spread and persistence (Wennström & Ericson 1992). Despite this, work on them is very limited. Here we analyse the effects of the floral-smut disease *Ustilago bullata* Berk. on the short-lived perennial grass *Bromus catharticus* J. Vahl. Specifically we use variations in plant density, soil nutrient levels and the relative frequency of infected and healthy plants in stands to provide a range of biotic and abiotic conditions against which to determine: (i) whether the effects of infection by *U. bullata* extend beyond a simple reduction of seed production; (ii) how infection affects the competitive ability of *B. catharticus* and allocation of resources within infected plants; and (iii) at what stages in the life cycle these effects are most apparent.

If male fitness of other trees were then disproportionately increased by increasing allocation to their male function (so increasing pollen transport), prior to flowering of the more 'female' phenotypes, then eventually, separate sexes might evolve. Given the pollination system and strong coupling of male and female function in figs, a separation of sexual function would have to involve adjustments in phenology, to ensure that pollinators are released in time to deliver pollen from male trees to female trees.

The scenario proposed by Kjellberg & Maurice (1989) led me to predict the following phenological patterns: (1) gynodioecious figs display seasonality in crop production; (2) female trees produce fruit synchronously only when conditions are favourable for seed germination and/or dispersal (e.g. during the monsoon season); (3) in seasonal environments, synchronous production of receptive syconia in female trees is preceded by synchronous production of receptive syconia in functionally male trees (e.g. during the dry season); (4) there is little temporal overlap in receptivity to pollinators between male and female trees; (5) the temporal separation of receptive peaks for male and female trees is the same as the time taken for pollinator larvae to develop; and (6) outside the main wasp-producing season, populations of the short-lived pollinator wasps are maintained through a series of small crops of figs produced by functionally male trees. Functionally male trees should therefore produce more crops than female trees and these additional crops should be produced out of the main fruiting season and should overlap within individual trees.

Discussion

VARIATION IN THE MUTUALISM, AND EVOLUTIONARY STABILITY OF THE STUDY SPECIES

The phenologies of the fig species studied reveal two evolutionary issues. Functionally male trees of *F. exasperata* have zero fitness out of the main syconium-producing season. At that time, when virtually no female trees produce inflorescences, wasps exit mature syconia on male trees and fly to receptive inflorescences on other male trees. Why therefore do male trees produce out-of-season crops? Out-of-season syconium production makes evolutionary sense if crops within the crowns of male trees of *F. exasperata* allow the pollinator life cycle to continue until the advent of the main receptive season. However, individual male trees of *F. exasperata* seem to produce very small, *nonoverlapping* crops of out-of-season syconia each year, although it is possible that some crops were missed because of the technical difficulty of spotting a few, green syconia on a tall, leafy tree. Even so, why should functionally male trees have significantly more out-of-season crops than female trees? Possibly, out-of-season receptivity is maintained at a higher frequency among male trees because of competition among 9 s es to pollinate the very small, occasional crops produced by females at that time. There is a very low level of out-of-season receptivity in female trees in both sites, and variation in the amount off-season rainfall at the study sites may occasionally allow successful germination of seeds produced out-of-season. The male that happened to pollinate a female at such a time could potentially be the sole sire of an entire crop of seeds. Given that, in reality, off-season rainfall is often too low to permit seed germination, I propose an alternative, provocative hypothesis: that out-of-season male receptivity is a remnant of the ancestral (monoecious) year-round receptivity phenology, maintained because the low cost of producing a few syconia in occasional years is offset by the very high benefit of maintaining a local wasp population.

Which are good introduction openers?

Introduction

Blushing is a well-known but relatively poorly understood phenomenon. According to Darwin (1), it is the 'most peculiar and the most human of all expressions'. Mark Twain (2) took this observation a step further, asserting that 'Man is the only animal that blushes. Or needs to'.

BLUSHING is the most peculiar and the most human of all expressions. Monkeys redden from passion, but it would require an overwhelming amount of evidence to make us believe that any animal could blush. The red-

Embarrassment is a common experience. It may be elicited by a surprising range of apparently dissimilar situations: being introduced to an unfamiliar audience, arriving at a social occasion under-dressed, talking to a person who stutters badly, mistaking a stranger for an acquaintance, and so on. Subjectively it entails a sense of exposure, of inadequacy, of awkward self-consciousness. It is sometimes accompanied by such distressing symptoms as

First sentence cannot overload the reader — must be quite snappy /.

Introduction

~~Saltmarshes are complex ecosystems where~~ Plants are subjected to a multiple array of stresses that include flooding, high soil salinity, anoxia, and the toxic chemical by-products associated with reducing conditions. Plant survival in stressful environments may be enhanced by many factors, particularly the formation of mycorrhizas (Janos 1980; Koske & Polson 1984). In general, mycorrhizas enhance survival by increasing nutrient acquisition and soil particle aggregation, as well as alleviating drought stress. However, mycorrhizal fungi are believed to require well-aerated soils (Harley 1959) and are considered poorly adapted to conditions in flooded environments (Mosse *et al.*

Introduction

Disease is ~~increasingly recognized as~~ a ~~potentially~~ powerful force in shaping plant population biology and plant communities (Dinoor & Eshed 1984; Bierzychudek 1988; Burdon 1991). The role that pathogens have in the ecology and evolution of their hosts is however, usually attributed to a single factor. For

Introduction

It is a common understanding that the species composition, structure and functional performance of vegetation is primarily determined by environmental factors operating at the local scale, such as air and soil temperature, soil moisture and nutrient availability (Grime 1979; Chapin 1980).

Introduction

Southwestern Australia has long excited the interest of botanists and biogeographers, being a region rich in angiosperm species, many of which are endemic. Within this region, a zone of particular importance has recently been delineated (Hopper 1979). This

The region is rich ...

Introduction

Host–pathogen interactions are typified by a wide variety of effects that have a diversity of consequences for the Darwinian fitness of both hosts and pathogens. Plant pathogens may kill their hosts rapidly (e.g. damping-off diseases: Augspurger 1983); cause individually small, but cumulatively debilitating effects on fecundity or longevity (e.g. rusts and mildews:

INTRODUCTION

The distribution patterns of insular species have fascinated biogeographers ever since Wallace's pioneering work in the Malay Archipelago during the nineteenth century (Wallace, 1892). Many early studies were descriptive, but after the publication of the equilibrium theory (MacArthur & Wilson, 1963) there was a revival of interest in island biogeography.

INTRODUCTION

The Western Australian Department of Conservation and Land Management (CALM) has initiated plantings of *Eucalyptus globulus* Labill. in excess of 6000 ha throughout the south-west of Western Australia (WA) (CALM 1992). Most of the planted area is on cleared

Which are the short, snappy sentences?

4 Average leaf life-span was 9 months. During an outbreak of the mangrove skipper *Phocides pigmalion*, insect herbivores shortened leaf life-span by increasing leaf abscission rate. Insect folivores reduced above-ground net primary production avail-

Results

EFFECT OF REMOVAL TREATMENT ON PLANT GROWTH

In both the xeric and mesic sites, plants which grew in the removal plots were significantly larger than those in no-removal plots. A repeated measures analysis (Gurevitch & Chester 1986; von Ende 1993) done in PROC GLM in SAS version 6.0. (SAS Institute 1989) shows that removal-plot plants had significantly more shoots per plant (Table 1, Fig. 2), and at the end of the experiment they also had greater above-ground dry mass (Fig. 2). Also, the plants in each block and treatment were smaller in 1992 than in 1991, although

In the xeric site there was no difference in 1992 size for plants that became infected between 1991 and 1992 and those that remained uninfected. In the mesic site, however, plants that became infected between 1991 and 1992 were significantly larger by 1992 (Table 4). This indicates that infection did not induce increased size in the xeric site, but may have done so in the mesic site.

clear sky. Radiation inside the glasshouse was 20% of that outside on a clear day, whilst radiation on a cloudy day was 14% of that on a clear day, so conditions inside the glasshouse were comparable to those which would obtain during cloudy weather.

This study compares the amino acid composition of the root xylem sap of the Western Australian root hemiparasitic shrub *Olax phyllanthi* (Labill.) R. Br. (Olacaceae) with those of a range of hosts in native habitat, using a mini extraction device to obtain vacuum-expressed xylem (tracheal) sap from specific parts of the root systems of host and parasite partner plants shown on excavation to be extensively interconnected by haustoria.

EFFECTS OF EH, %H_2O, AND ROOT BIOMASS ON THE VERTICAL DISTRIBUTION OF AM

Surprisingly, mycorrhizas were present in soils with low sediment Eh in each site. In some cases where Eh < 100 mV, %AM exceeded 30% (Fig. 4). In

The root xylem sap of parasitic plants contained noticeably higher relative proportions of Asn, Asp and Gln than were present in tissue pools, suggesting strong selection of these solutes for transport as opposed to storage (Fig. 2).

Conservative water use in high salinity (Ball 1986, 1988; Lin & Sternberg 1992; Ball & Passioura 1994), production of defensive tannins (de Lacerda *et al.* 1986; Jayasekera 1991), and increased leaf thickness (Feller 1995) extract maintenance 'costs' that reduce *RGR* and *NAR*, and that are potentially reflected in increased leaf life-span and decreased growth rate (Reich *et al.* 1992). Salinity effects on total respiration

Good flow

Olax–Anthocercis viscosa *association (Fig. 4b)*

The xylem of this host exemplified the xylem of many species in the habitat in which Gln was the major translocated amino compound. Yet, while this compound represented 60% of the total amino acids (molar basis) of *Anthocercis*, it comprised a mere 5% of the endophytic tissue pool and only 13% of the xylem amino compounds of the attached *Olax*. Conversely, Pro, Ala, Ser, Asn and Gab featured prominently in *Olax* but comprised only traces of the xylem pool of the host. Yet again, Sec was recovered only from the parasite.

Infection of host plants by *U. bullata* may occur through either: (i) penetration of the coleoptile of germinating seed (seedling infection); or (ii) direct infection of young tillers (shoot infection). Of the two

Which are good statements of aims?

The rain-forest canopy is very different from the understorey layers in physical environment, biomass distribution and species composition (Elton 1973; Perry 1978; Lowman 1985). Few studies have been conducted in the upper canopy, however, despite the fact that it is the largest component of the forest both spatially and in terms of productivity. This apparent neglect probably reflects the logistical problems of access. Fortunately, the recent development of technical climbing apparatus (Perry 1978) has facilitated vertical ascent into treetops. Canopy research has been summarized by Mitchell (1982), and is expanding (e.g. Nadkarni 1984; Lowman 1985), but many questions remain unanswered.

In this study, cohorts of leaves in a rain forest were examined for growth, survivorship and mortality to answer the following questions:

1. What factors affect the patterns of leaf growth dynamics within and between Australian rain-forest trees?

2. What are the rates of turnover of leaf material to herbivores and decomposers?

3. How do grazing and leaf-fall patterns vary on spatial and temporal scales?

4. How much leaf material exists in a mature rain-forest canopy at any one time?

Genetic variation for resistance to pathogens ne to be documented (Fritz & Simms 1992), since this a necessary condition for pathogens to act as evolutionary agents of selection in natural host plant populations (Alexander 1992). Experimental studies have detected striking genetically based variation in resistance (e.g. Day 1978; Miles & Lenne 1984; Burdon 1987b; Parker 1988, 1991; Alexander 1989), although they rarely test for variation in resistance due to environmental factors (but see Jarosz & Levy 1988). Thus, it is difficult to evaluate whether such genetic variation in resistance translates into a meaningful effect under naturally heterogeneous conditions.

To test the main effects of and the interactions between three potentially important factors, replicate sets of *Juncus* genotypes grown with and without heterospecific neighbours in plots which spanned a heterogeneous environment were inoculated with the smut fungus. To identify more accurately the effects of the chosen factors, other factors of potential importance in plant–pathogen interactions were experimentally controlled. These included host plant density, host developmental stage, host plant population genetic structure, and pathogen inoculum source.

?e not listed here

Summary

1 Clonally propagated individuals of *Juncus dichotomus* were exposed to the flower-infecting smut fungus pathogen *Cintractia junci* in two sites in a two-year field experiment. The effects and interactions of three factors – the presence of heterospecific neighbours, environmental heterogeneity, and plant genotype determined by allozymes – were tested. Host plant density, population genetic structure, and pathogen inoculum source and quantity may also influence infection and were therefore held constant.

vague

This paper investigates the importance of the light environment in providing a basis for ecological separation in *V. chamaedrys*, *V. montana* and *V. officinalis*. The impact, and duration, of the response to canopy shading for perennial, decumbent clonal species that may be capable of foraging for resources (Slade & Hutchings 1987) is also discussed.

A field trial was established to assess growth and recovery responses of *E. globulus* saplings to different amounts of manual defoliation applied over the course of the first year of growth. Treatments applied in this trial were intended to emulate the gross effects of defoliators such as spring beetles (Scarabaeidae), grasshoppers (*Phaulacridium vittatum, Chortoicetes terminifera*) and autumn gum moth (*Mnesampela privata*). We addressed three questions:

(1) Does defoliation affect height and diameter growth in young *E. globulus*?

(2) Does the season of defoliation affect growth responses to defoliation?

(3) Do growth responses to defoliation persist?

An investigation into stand dynamics is a prerequisite to understanding development along the self-thinning surface of mixed-species populations. Population dynamics can then be integrated with the size–density relationship into a growth model. Smith & Hann (1986) developed two monospecies growth models based on the size–density relationship for stands of *Alnus rubra* seedlings and *Pinus resinosa* (red pine) by incorporating a mortality equation. However, growth models for mixed-species populations require additional information about (i) population structure or relative dominance of one species and (ii) the species proportions in the mixture.

In this study, these factors are incorporated into a simple system to improve understanding of the size-density relationship and its underlying dynamics in mono- and polycultures using *Alnus rubra* Bong. (red alder) and *Pseudotsuga menziesii* (Mirb.) Franco (Douglas fir) stands as an example. *A. rubra* and *P. menziesii* were chosen because of their widely overlapping distribution in the Pacific Northwest (Fowells 1965) and because interest in management of mixed *A. rubra*–*P. menziesii* stands has increased (Tarrant *et al.* 1983). On some sites they are severe competitors (Cole & Newton 1987; Shainsky 1988); on other sites *A. rubra* enhances *P. menziesii* growth due to its nitrogen-fixing ability (Tarrant 1961; Miller & Murray 1978). The main objective of our study was to extend the size–density concept to mixed-species populations and to investigate its underlying dynamics.

Which are good discussion openers?

Discussion

In the Walker Creek tidal saltmarsh, different flooding regimes at the three sites had a significant effect on the extent of mycorrhizal colonization in *Jaumea carnosa*. The upland site supported the lowest levels of %AM, arbuscules, and coils, despite low phosphorus availability. Conditions in this site alternated seasonally between periods of flooding due to heavy rainfall and extremely dry periods when the water table dropped and salinity levels exceeded those for either the channel or marine sites (Brown 1994). These results suggest that AM develop poorly in saltmarsh soils that are not buffered by constant tidal action.

Plants nearest the tidal channel exhibited significantly higher levels of %AM compared to the more flooded marine and seasonally dry upland sites. The channel site was characterized by moderately low soil phosphorus availability and high levels of inorganic nitrogen. Although average salinity levels were

---

Discussion

Our study sites included six different mire types (four herbaceous: BH, FH, RH and TH and two forested: BF and FF) most of which occurred in both study areas. General trends can be observed among these types, regardless of the differences between the two study areas. Cotton tensile strength loss provides an index of overall potential decomposition in the soils studied (see Harrison *et al.* 1988); as a standard substrate (i.e. cellulose) is introduced, no allowance is made for differences in litter quality. Decomposition rate determined in this way was low in the bog sites and higher in most of the fen sites and was controlled by soil base status and soil P richness. The inhibition of decomposition under acid conditions has previously been found in experimental studies (Swift *et al.* 1979; Leuven & Wolfs 1988). The relation with soil P richness has not generally been found suggesting that the microbes breaking down the cellulose may have experienced P shortage in some of our sites. Nitrogen has more commonly been found to control decomposition rates (Melillo *et al.* 1984; Van Vuuren *et al.* 1992), although the role of phosphorus has often been neglected in decomposition studies (Couteaux *et al.* 1995).

N mineralization tended to be faster in the forested than in the herbaceous mires. Here, the nutrient richness of the interstitial soil water explained much of the variance. It is hard to say whether the high N concentrations in the water were the cause or the effect of the high mineralization (see also Williams & Wheatley 1988; Hayati & Proctor 1991). Hill & Shackleton (1989) showed that high inorganic N concentrations stimulated organic N recycling. The vari-

---

Discussion

Morgan & Smith (1979) suggested that a phytochrome-controlled response is an adaptation for redirecting growth according to the degree of shading because the ratio of far-red-activated to red-activated phytochrome (P_{fr}:P_{total}) found in shaded plants is almost linearly related to the ambient R:FR ratio. Changes in P_{fr}:P_{total} result in internode elongation is species typical of unshaded habitats (Grime 1965; Holmes & Smith 1975; Frankland & Letendre 1978), but elongation is less pronounced in species of shaded habitats (Morgan & Smith 1979; Corré 1983b). Shade plants, by definition, grow beneath other vegetation and do not mobilize carbohydrate for stem extension to the same degree as do sun species (Smith 1982), which may be able to overgrow smaller competitors in the short term. The morphological responses of sun species to canopy shading are variable. For example, the *SLA* of *Chenopodium album* exhibits a response to R:FR ratio whilst that of *Rumex obtusifolius* does not (Morgan & Smith 1981). The prostrate chamaephyte life-form of *V. montana*, *V. chamaedrys* and *V. officinalis* (Raunkiaer 1934), in which internal support is insufficiently developed to allow continued vertical growth (Niklas & O'Rourke 1982), determines that these species will remain in the lowest stratum of stratified vegetation. Their ecological distributions infer, however, that they differ in their ability to tolerate shading in the long term.

The three *Veronica* species did not differ in their growth efficiency (*RGR*), which was reduced by both a lower *PFD* and R:FR ratio, a response shown by *Rumex obtusifolius* (McLaren & Smith 1978). In contrast, *ULR* was insentitive to spectral distribution, as reported previously (Corré 1983b). The relationship between *ULR* and *PFD* seldom explains species' ability to tolerate shade (Blackman & Black 1959; Pons 1977). Instead, changes in *LAR* are responsible for the maintenance of *RGR* in shade via an increase in the size of the photosynthetic system rather than in its efficiency (Blackman & Wilson 1951; Grime 1965; Pandey & Sinha 1977). Insofar as *LAR* increased with decreasing *PFD*, *V. montana*, *V. chamaedrys* and *V. officinalis* all exhibited some adaptation to shade. Corré (1983a) argues that it is response to light *quality* that determines a species' capacity to adapt to shade. The inhibitory effect of far-red stress on the ability to increase *LAR* in both *V. montana* and *V. chamaedrys*, contrasted with the maintenance of *LAR* in *V. officinalis*, suggests superior morphological adaptability to shade in *V. officinalis*. Consequently, the response of *LAR* cannot explain the ecological distribution of the three species with respect to the light environment. Nevertheless, the magnitude of *LAR* confers greater leafiness per unit biomass to canopy-shaded plants of *V. chamaedrys* and *V. montana* compared to *V. officinalis*.

Which are good discussion openers?

Discussion

Structure, overall, appears to hold the key to understanding the dynamics of the mature phase of mixed dipterocarp forest. However, the analysis of patterns of structural variation through use of quantitative data from profile diagrams which represent a small area of forest can at best provide a first approximation. The study plots, consciously sited to avoid recognizable gaps, initially provided information concerning the dynamics of late-building and mature-

---

Discussion

The experiments reported here, taken together with previous experiments and with cross-species correlations with shaded habitat, present a reasonably coherent picture. Consistent with earlier glasshouse experiments by Grime & Jeffrey (1965), Hutchinson (1967) and Leishman & Westoby (1994), cotyledon-stage seedlings from larger-seeded species tended to survive longer in deep shade.

Discussion

THE EFFECTS OF NEIGHBOURING PLANTS

In this system, nonhost plant neighbours had a strong direct negative effect on host plant growth, but also had an indirect effect on the plant–pathogen interaction, being beneficial to the host plant by keeping infection at bay. In a site where a pathogen exerts strong selective pressure on its host plant, by being very abundant or very virulent, there may be a long-term selective advantage to a plant that can survive and reproduce under very competitive conditions if it also escapes infection because of the presence of nonhost neighbours. In turn, this could promote higher diversity in plant communities. Previous suggestions that pathogens and other pests promote species diversity is based on the observation that epidemics are more common in monocultures (Burdon 1987a), and emphasizes the barrier effect of nonsusceptible plants (see below). Here the suggestion is that the presence of nonhosts as competitors could have additional effects.

There are at least five ways that plant neighbours may be important in a plant–pathogen interaction, and three of these are a consequence of plant competition. First, a plant that is physiologically stressed due to resource depletion by competitors may have inadequate resources for defense against parasites, predisposing it to disease (Clay 1990b). Host physiological changes that predispose plants to infection have been shown in a variety of systems. Stress factors tested include light, heat, mineral nutrition, moisture, and defoliation (Yarwood 1956; Colhoun 1979;

Discussion

GROWTH ANALYSIS AND ESTIMATES OF PRIMARY PRODUCTIVITY

Growth analysis is widely used to describe patterns of increase and partitioning of plant biomass (e.g. Evans 1972; Hunt & Lloyd 1987) and module production (e.g. Bazzaz & Harper 1977; McGraw & Garbutt 1990), and to elucidate commonalities in plant growth strategies among plant communities and successional seres (e.g. Grime & Hunt 1975; Reich *et al.* 1992; Ackerly 1995). In combination with demographic studies, plant growth analysis can link ecophysiological processes, such as photosynthesis and transpiration, with ecosystem parameters, such as carbon gain, net primary production and litter production rate (Chapin 1993; Clark 1993; Schmid & Bazzaz 1994). However, mangroves are absent from even the most comprehensive reviews of successional processes in tropical forests (Bazzaz & Pickett 1980; Reich *et al.* 1992; Ackerly 1995). Data on demography, growth and postdisturbance dynamics of mangroves, are rare (Snedaker *et al.* 1992; Ellison & Farnsworth 1993; Smith *et al.* 1994; Clarke 1995), but these data are needed to permit accurate scaling of individual-level processes up to models of ecosystem dynamics.

Our data indicate that different populations of *R. mangle* saplings exhibit constant allometric scaling relationships (*sensu* Niklas 1994) across locations between standing numbers of modules, such as leaf pairs per cm of shoot, shoot length per shoot, leaves per shoot, leaves per number of aerial roots, and number of shoots per number of aerial roots (Fig. 2, Table 2). Root length does vary plastically among cays, with possible implications for mangrove responses to different sedimentation regimes (Table 2). Overall, the relatively tight conformity of *R. mangle* to its 'standard' growth form in this carbonate platform setting enables us to calculate biomass gain parameters reliably from simple nondestructive *in situ* measurements (Tables 3 and 4).

DISCUSSION

Shortcomings in the dataset used indicate that caution must be used in drawing conclusions about patterns of occurrence of mammal species, and about the effect of introduced exotic species on extinctions of native species on islands. First, because data were collected only for mammal occurrences, either of indigenous or exotic species, fewer islands with no indigenous species were observed than might be expected. Secondly, detection of statistically significant effects other than area on the pattern of individual species occurrences was related to sample size. Thirdly, the pattern of introductions of exotic species constitutes a 'natural experiment', and drawing conclusions about the effect of introduced species on the native fauna is thus difficult. Consequently, two species known to be strongly associated with species extinction on the Australian mainland, *Felis catus* and *Vulpes vulpes*, could only be clearly associated with a single island extinction.

Good conclusions

Conclusion

The complexity of interactions between plants and their pathogens in natural communities is demonstrated by this experiment. In this system, whether or not a particular plant becomes a host to the smut fungus is influenced by its surrounding plant neighbours via their effects on its size and/or vigour, which patch of a patchy environment it happens to be rooted in, and, under some conditions, the plant's own genotype. Undoubtedly other factors that were either controlled or not even considered here would also be influential. Certainly, field experiments attempting to understand natural plant–pathogen interactions need to include a reasonable array of likely factors that influence whether plants become infected. When we understand what these factors are and how they may interact then we will be in a better position to determine the natural conditions under which pathogens are important in the ecology and evolution of plant populations.

Growth loss and death of trees from single large defoliations were surprisingly small. However, our experiment did not address the impact of frequency of defoliation on growth of *E. globulus*. If *E. globulus* behaves similarly to *E. marginata*, more frequent defoliations of low intensity should reduce growth more than less frequent defoliations of higher intensity (Abbott *et al.* 1993). The concern of plantation managers should therefore be directed at the more severe consequences of regular, small defoliations. This is why *E. globulus* plantations and timberbelts in WA require regular monitoring of pest insect densities. This will allow more informed usage of chemicals for protecting the wood resource from the effects of insect outbreaks and will direct the attention of managers to the vulnerability of partially defoliated trees to further damage.

---

5 Demographic growth analysis is a powerful tool with which to predict dynamic responses of module production and whole-plant growth in response to local environmental conditions. Our analyses illustrate that growth of mangroves are sensitive to seasonal patterns of insolation, to decreasing sedimentation and to increasing water depth. Given that growth of mangrove saplings on coral cays declines significantly with sedimentation rate, persistence of these forests is unlikely if sea level in the Caribbean increases as predicted.

---

5 The results indicate that field experiments on plant–pathogen interactions should consider a range of causal factors. Only then can the complexity of these systems be understood, and the conditions under which disease is important in the ecology and evolution of plants be evaluated.

Summary

1. A multivariate analysis of 43 traits of 300 species from semi-arid woodlands in western New South Wales, Australia is described. The 43 traits encompass vegetative, life-history, phenological and seed-biology characters.

2. Five main groups of species were produced which corresponded largely to growth form. These groups were (i) perennial forbs and C3 grasses, (ii) subshrubs of the family Chenopodiaceae, (iii) perennial C4 grasses, (iv) trees and shrubs and (v) annual forbs and grasses. The traits associated with these groups were vegetative, life-history and phenological. Seed-biology traits were poorly associated with the groups.

3. There were higher percentages of associations within and between vegetative, life-history and phenological traits, than within seed-biology traits. This has important consequences for models of vegetation dynamics in the context of species migrations under global climate change, as these models group species largely on the basis of their vegetative and life-history attributes.

Waffle