Chapter 6

BIODIVERSITY OF AUSTRALASIAN INSECTS

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Much Australasian biodiversity, lacking the decimating effects of the predominantly northern hemisphere Pleistocene glaciations, remains intact – from a much deeper geological history. To the alert and traveled northern hemisphere scientist, the biodiversity to the south of the equator is much more extravagant than to the north. For example, a higher taxonomic diversity of ants is recorded for a modestly revegetated hill outside the Australian National Insect Collection Laboratories in Canberra than in all of the UK. Furthermore, Australasian biodiversity displays biogeographic patterns uniting the southern continents, as recognized by early explorer–scientists such as coleopterist Wilhelm F. Erichson (1842) and polymath Hooker (1853), both of whose placements of the fauna and flora of ‘Van Diemen’s Land’ in a global context were remarkably prescient. Southern hemisphere-based entomologists such as Mackerras (1925), Tillyard (1926), and Harrison (1928) recognized austral biodiversity relationships prior even to knowing of Wegener’s (1915, 1924) theory of continental drift. The lesson is that a detailed knowledge of the geology and biodiversity of the southern lands, with a comparative perspective, allowed intellectually untrammled minds to understand the evolution of the biota, despite contrary geological orthodoxy. We might consider if similar constraints are hindering our deeper understanding of the diversification of austral insect biodiversity (McCarthy 2005).

**AUSTRALASIA – THE LOCALE**

Australasia, for the purposes of this overview, comprises the series of oceanic islands, from massive to minute, in the southwestern Pacific (Fig. 6.1). It corresponds with the geological Australian section of the Indo-Australian Plate, and thus is flanked to the west by the Indian Ocean and to the south by the Antarctic/Southern Ocean. The island continent of Australia (including Tasmania) is the largest landmass, with the globally largest ‘official’ island of New Guinea to its north, and New Zealand to the southeast. The Australian islands of Lord Howe and Norfolk lie successively to the east, with New Caledonia northeastward, then Vanuatu (New Hebrides) and further eastward, Fiji in the eastern Melanesian Region of the Central Pacific, almost astride the boundary between the Australian and Pacific plates. Tonga lies southeast on its own microplate (terrane).

The biotically defined northwestern boundary to Australasia often is treated as Wallace’s Line, named for Alfred Wallace who recognized a faunal discontinuity between the ‘Australasian’ islands of Celebes (Sulawesi) and Lombok (to the east) and Indo-Malayan islands including Borneo, Java, and Bali (to the west). The Indonesian islands on the Australian side, termed Wallacea, are separated by deep water from both Indo-Malaysia and the Australia-New Guinean continental shelf. Wallace’s noted discontinuities are less evident among insects, or at least the patterns are
so complex, especially concerning Sulawesi, that a simplistic interpretation is not possible (Vane-Wright 1991, New 2002) – an issue also interpretable as ‘too many lines . . . ’ (Simpson 1977). This region is perhaps best understood as transitional – having an Australian/New Guinean faunal resemblance that is variably attenuated with distance westward, and overlies a rich and highly endemic biota, often with continental Asian affinities that attenuate eastward. In this area, only Christmas Island (10° 30′ S 105° 40′ E), an Indian Ocean offshore Territory of Australia, will be considered in this chapter.

Although New Zealand lies close to and astride the eastern margin of the Pacific Plate, with the Alpine fault plate boundary running southwest–northeast across its South Island, here all of New Zealand and its offshore, including subantarctic, islands are considered. These latter represent remnant emergent islands of the Campbell Plateau, lying between Antarctica and South Island New Zealand, and carry biotas exhibiting both endemic and widespread elements (Michaux and Leschen 2005).

SOME HIGHLIGHTS OF AUSTRALASIAN INSECT BIODIVERSITY

Insects ‘down under’ contain iconic exemplars. The bush fly Musca vetustissima provokes the famous Aussie ‘wave’ and promotes the tourist’s souvenir cork-lined hat. The attentions of one of the most abundant and diverse ant faunas in the world authenticate the famous ‘Aussie barbecue’. The landscape of northern Australia is characterized by termite mounds of diverse shapes and sizes, among the most striking of which are the flattened and regularly north–south orientated structures produced by the magnetic termites (Amitermes spp.). Public attention was captured by the rediscovery and recovery of the presumed extinct Lord Howe Island stick insect (Deinacrida heteracantha or wētāanga (Maori for ‘god of ugly things’), one of the heaviest insects, weighing up to 70 g (Trewick and Morgan-Richards 2004). About 1 million tourists each year visit Waitomo Caves (Doorne 1999) to share an extravagant and potentially educational entomological experience – the bioluminescence displayed by glowworms, larvae of the dipteran Arachnocampa luminosa (Keroplatidae). For conservation of native biodiversity, Aotearoa (the Maori name for New Zealand) has one of the highest profiles of any country, following recognition of the devastation caused to the unique native invertebrates and birds after the arrival of humans, both Polynesians and European colonists, with their attendant rats and peridomestic animals. Invertebrates feature in many species conservation plans, which depend substantially Australia, once formed another important Aboriginal food. The nocturnal illumination of a new Parliament building in the nation’s capital acted as a giant light-trap for migrating bogongs in such numbers that the insects entered the politicians’ consciousness and inspired the design for a Canberra-based meeting of the Australian Entomological Society (Fig. 6.2).

Fig. 6.2 Logo for the Annual Australian Entomological Society meeting, incorporating bogong moths and National Parliament Building Canberra.
on elimination of vertebrate vermin from offshore islands.

Central to many of the southern biogeographical studies has been the island of Nouvelle Calédonie (New Caledonia). The French have a long history of biodiversity studies in their erstwhile colony, with entomologists prominent among researchers. Early studies, notably of the flora, suggested the existence of an ancient, relictual fauna that survived from the Cretaceous Gondwanan megacontinent. Although that thesis stimulated global scientific interest, the scenario is not quite as once believed, at least for insects. Nonetheless, this does not negate the evidently high levels of endemism, and multiplicity of evolutionary origin of the biota.

To the north, New Guinea, the second largest island on the planet, is separated from the Australian continent only by the relatively shallow and recent Torres Strait. This geologically (and ethnically) diverse island might have been a lesser target for pioneering exploratory entomologists, compared to the rainforests of Southeast Asia and the Amazon. However, early insect collectors discovered many gaudy, and perhaps saleable specimens such as the largest known butterfly in the world, the Queen Alexandra’s birdwing (Ornithoptera alexandrae); the world’s largest moth, the Hercules moth (Coscinocera hercules); and giant stick insects (Eurycnema goliath and species of Acrophylla).

Biologist-explorers of New Guinea, including Wallace (1860) and D’Albertis (1880), collected and recorded extraordinary insect diversity for a nineteenth-century European audience eager for natural history tales and specimens. Papua New Guinea (PNG) (eastern New Guinea) ranks twelfth globally in terms of endemism of large butterflies (Papilionidae, Pieridae, Nymphalidae), with 56 of 303 species endemic. Economic benefits can flow from a perhaps sustainable trade in such live lepidopterans for the butterfly houses of the affluent world. More recently, the island has been the site of some laborious and intensive studies of plant-feeding (phytophagous) insects in an attempt to establish how selective these insects are in their use of host plants such as the diverse figs (Ficus).

In keeping with the predictions of island biogeographic theory, Pacific Islands, including New Zealand, have harmonious biotas, typically with major taxa erratically absent, some groups showing evidence of endemic radiations, and generally high levels of endemism. These islands, and especially Hawai‘i, are the theaters in which the processes of species formation and species extinction can be studied, for mixed in with the natives are substantial alien introductions that threaten all aspects of biodiversity retention.

The Lord Howe Island stick insect

The Lord Howe Island Group is located in the Western Pacific Ocean, some 700 km northeast of Sydney and comprises the main island of Lord Howe, as well as Admiralty Islands, Mutton Bird Islands, Ball’s Pyramid, and many reefs. Geologically, the main island is the eroded remnant of a large shield volcano that erupted intermittently from the sea floor in the Late Miocene (some 6.5–7 mya). What remains are the exposed peaks of a 65-km long and 24-km wide volcanic seamount that rises from ocean depths of nearly 2 km. The seamount is near the southern end of a chain of such seamounts, most of which are submerged; the chain extends for more than 1000 km. The seamount is near the southern end of a chain of such seamounts, most of which are submerged; the chain extends for more than 1000 km.

The Group was inscribed on the World Heritage List in 1982 as an outstanding example of an oceanic island of volcanic origin, with a unique biota and important and significant natural habitats for in situ conservation of biological diversity, including those containing species of plants and animals of outstanding universal significance from the point of view of science and conservation. Although no insects were specified in the nomination, subsequently the island has attained some fame as the site of the rediscovery of a large, flightless, stick insect (Fig. 6.3). The Lord Howe Island stick insect, D. australis (Montrouzier), was known locally as the ‘land lobster’ or ‘tree-lobster’ (Fig. 6.3)
on account of its shape and size (up to 12 cm long). This phasmid was known for its ability to run on the ground. It was common and easily observed sheltering in banyan trees (*Ficus macrophylla*) on the island early last century. Its demise appears to have been connected with the release of black rats on the island when a supply ship ran aground in 1918, triggering extinction of five flightless birds; the land lobster was believed to have become extinct by the 1930s, and was entered as such in the IUCN (International Union for Conservation of Nature and Natural Resources) Red List. Subsequent surveys failed to find any further evidence, until a rock climber on the offshore Ball’s Pyramid photographed an adult female; its rare presence was confirmed in the late 1980s. Ball’s Pyramid is aptly named, being a pyramidal structure rising 500 m above sea level from a base of only 1,100 × 400 m at sea level. The idea that such a basaltic column, lacking both large woody vegetation and refugial hollows, could support a population of a large phasmid was greeted with skepticism. Numerous attempts to rediscover the species failed until in 2001 a biological survey revealed three specimens associated with the endemic shrubby paperbark (*Melaleuca howeana*). The following year, 24 individuals were observed associated with the same, small patch of paperbark, believed to be the only suitable habitat on the island. Retreats were crevices in the rock–root interface where seepages occurred, in contrast to the tree holes used on the mainland prior to extinction. The rediscoverers (Piddel *et al.* 2003) pointed out that the Ball’s Pyramid locality is too small to maintain a population against any future environmental change and made a plea for a captive-breeding program, concurrent with elimination of rats from Lord Howe, to allow re-introduction. Action plans prepared by the New South Wales National Parks and Wildlife Service (NSW NP and WS) followed the Commonwealth Government listing of the species as critically endangered (from extinct). Two pairs of the insects were housed by one of Australia’s leading stick insect experts. Rearing has been successful using garden-grown *M. howeana* as the food stock, with banyan in reserve (Zoos Victoria 2006). The necessary elimination of rats from Lord Howe Island, required for any reintroduction to succeed, remains under consideration for feasibility and cost.

### Australasian birdwing conservation

The world’s largest butterfly, the Queen Alexandra’s birdwing (*O. alexandrae*) of PNG, is a regional success story. This spectacular species, whose caterpillars feed only on *Aristolochia diehlsiana* vines, is limited to a small area of lowland rainforest in northern PNG. Under PNG law, this birdwing species has been protected since 1966, and international commercial trade was banned by endangered listing on Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Dead specimens in good condition command a high price, which can be more than US$2,000. In 1978, the PNG governmental Insect Farming and Trading Agency (IFTA), in Bulolo, Morobe Province, was established to control conservation and exploitation and act as a clearinghouse for trade in Queen Alexandra’s birdwings and other valuable butterflies. Local cultivators, numbering some 450 village farmers associated with IFTA, ranch their butterflies. Farmers plant appropriate host vines, often on land already cleared for vegetable gardens at the forest edge, thereby providing food plants for a chosen local species of butterfly. Wild adult butterflies emerge from the forest to feed and lay their eggs; hatched larvae feed on the vines until pupation when they are collected and protected in hatching cages. According to species, the purpose for which they are being raised, and conservation legislation, butterflies can be exported live, as pupae, or dead as high-quality collector specimens. IFTA, a nonprofit organization, has sold some $400,000 worth of PNG insects yearly to collectors, scientists, and artists around the world, generating an income for a society that struggles for cash. Local people recognize the importance of maintaining intact forests as the source of the parental wild-flying butterflies of their ranched stock. In this system, the Queen Alexandra’s birdwing butterfly has acted as a flagship species for conservation in PNG, and this success story attracts external funding for surveys and reserve establishment. In addition, conserving PNG forests for this and related birdwings undoubtedly results in conservation of much biodiversity under the umbrella effect. The UK Darwin Initiative in 2005 funded a 3-year project ‘Socio-economics of insect farming in PNG’ to assess and train in sustainable insect collecting. Early reviews suggest that burdensome licensing, permits, fees, and paperwork threaten the viability of legal trade and encourage a growing illegal trade especially in abundant species that ought to need no CITES listing.
New Guinean insect conservation efforts need a commercial incentive to provide impoverished people with some recompense for protecting natural environments. Commerce need not be the sole motivation; however, the aesthetic appeal of native birdwing butterflies flying wild in local neighborhoods, combined with local education programs in schools and communities, has saved the subtropical Australian Richmond birdwing butterfly, *Troides richmondia*. Larvae of Richmond birdwings eat *Pararistolochia* or *Aristolochia* vines, choosing from three native species to complete their development (Sands et al. 1997). However, much coastal rainforest habitat supporting native vines has been lost, and the alien South American *A. elegans* (Dutchman’s pipe), introduced as an ornamental plant and escaped from gardens, has been luring females to lay eggs on it as a prospective host. This oviposition mistake is deadly because this plant is toxic to young caterpillars. The answer to this conservation problem has been an education program to encourage the removal of Dutchman’s pipe from native vegetation, from sale in nurseries, and from gardens and yards. Replacement with native *Pararistolochia* was encouraged after a massive effort to propagate the vines. Community action throughout the native range of the Richmond birdwing appears to have reversed its decline, without any requirement to designate land as a reserve (Sands et al. 1997).

DROWNING BY NUMBERS? HOW MANY INSECT SPECIES ARE IN AUSTRALASIA?

**Australia**

For the total Australian insect diversity, Taylor (1983) estimated about 110,000 species. Even then, this figure clearly was an underestimate. After questioning of practicing taxonomists, Monteith (1990) determined a figure of about 20,000–40,000 beetle species, although what proportion of the total biota this constituted was unknown. Suggesting that the Australian dipteran fauna of some 10,000–12,000 species and the Australian insect fauna as a whole both comprise about 5% of their respective world totals, Collens and McAlpine (1991) extrapolated to estimate global diversity in the low- to mid-range of existing estimates. Stork (1993) then suggested the existence of some 400,000 Australian insect species, of which three-quarters were undescribed. In extrapolating from comparatively well-known geographically constrained regions to generate global biodiversity estimates, Gaston and Hudson (1994) included the Australian insect biota in their analyses as ‘well known’. They argued that the more modest Australian species richness estimates supported their own estimated low value for total global species richness. Most recently, a combination of expert opinion with extrapolation from the rate of species discovery by recent revisionary taxonomists, led Yeates et al. (2003) to a figure of near 205,000 insect species for Australia. Within this estimate, numbers of described and estimated species range from only 10 undescribed species among the estimated 3,300 Odonata, to some 60,000 undescribed Coleoptera, with only 22,000 described. The major (megadiverse) orders include estimates of 12,000 Hemiptera; 20,000 Lepidoptera; 50,000 Diptera; and 40,000 Hymenoptera. Coleoptera comprise about 40–50% of the total numbers of insects. The authors acknowledge shortcomings, including some related to revisionary taxonomists’ choices of study taxa – some selected their taxa due to high levels of perceived novelty (upwardly biasing extrapolates), whereas others, reviewing already well-known taxa (e.g., butterflies), contributed little in the way of species discovery (biasing downward). These figures, nonetheless, seem to reflect a reality in which Australia, with some 6% of the earth’s land area, supports about 5–6% of the global insect species diversity of some 4 million species.

**New Zealand (Aoteaoroa), Chatham Islands, and Subantarctic Islands**

New Zealand, comprising two main islands with an area much smaller than Australia (0.27 versus 7.6 million square kilometers), supports a commensurately lower insect biodiversity. A preliminary assessment (for Species 2000 New Zealand) provides an estimate of some 20,000 species, among them slightly more than 10,000 described species, and nearly 9000 species awaiting description. Kuschel’s (1990) claim of 40,000 species, based on extrapolation from a rather exaggerated Coleoptera diversity, seems too high, especially because Leschen et al. (2003) assess the New Zealand Coleoptera at approximately 10,000 species. Insects on New Zealand’s offshore islands have been subject to continuing study, especially the beetles.
Thus, addition of 131 species of Coleoptera to the known fauna of Chatham Islands (ca. 40°S) increased the total to 286 (Emerson 1998). Smaller, perhaps younger, and increasingly southerly (subantarctic) islands, emergent from the Campbell Plateau, have more modest insect biodiversity, at least as far as numbers alone are concerned. Of 150 insect species reported from the Antipodes Islands (ca. 49°S) (Marris 2000), Coleoptera comprise only 25 species in 13 families. In comparison, the Snares Islands (48°S) have a reported 25 species in 14 families; the Bounty Islands (ca. 47°S), 9 species in 7 families; the Auckland Islands (ca. 50°S), 57 species in 17 families; and Campbell Island (ca. 52°S), 40 species in 15 families. The most austral island in the area, the Australian Macquarie Island (54.10°S), has eight species in only two families (Williams 1982, Greenslade 1990, Young 1995, Klimaszewski and Watt 1997, Marris 2000).

These data suggest that the island faunas are species poor and, under these circumstances, the use of standard multipliers from the known Coleoptera fauna to the total Insecta fauna might be misleading. This scenario is especially so on oceanic islands with unbalanced faunas and different histories and distances from sources. The question of endemism and biogeographic and phylogenetic relationships of the insect faunas of New Zealand will be considered later.

New Guinea

From ratios of the New Guinea (NG) fauna to the world fauna for well-known groups, rates of description of new taxa, and the size of the Australian insect fauna, Miller et al. (1995) calculated a possible 300,000 species of insects for New Guinea. They qualified this figure as potentially overestimated or underestimated by 100,000 species. More recently, biodiversity surveys assessing richness of phytophagous (plant-feeding) insects have delivered further insights. Insect herbivores sampled from the foliage of 15 species of figs (Ficus, Moraceae) in rainforest and coastal habitats in the Madang area, Papua New Guinea, revealed 149 species of leaf-chewing insects (13,193 individuals) and 450 species of sap-feeding insects (44,900 individuals) (Basset and Novotny 1999). Despite a high sampling intensity, the species-accumulation curve did not reach an asymptote. Evidence from studies such as this, concerning host specificity of phytophagous insects in New Guinea, led Novotny et al. (2002) to challenge previous large multipliers based on high levels of monophagy. Based on an estimate that New Guinean Coleoptera and Lepidoptera constitute 5% of the global biodiversity of each order, a proportion derived from Sekhran and Miller (1996), new regional and global biodiversity estimates were derived from host-specificity ratios. For butterflies, for which figures of 959 described species in New Guinea (Parsons 1999) and 15,000–20,000 species globally are likely to be accurate, Novotny et al. (2002) calculated an estimated 1179 species in New Guinea and 23,500 worldwide.

New Caledonia and the West Pacific

New Caledonia (NC) lies on the Tropic of Capricorn, between 19° S and 25° S, 1200 km due east of Capricornia, Australia, and 1500 km northwest of New Zealand. The island is a recognized biodiversity hot spot. Some 4000 insect species had been cataloged at the time of Chazeau’s (1993) review of the terrestrial fauna of the island, but an estimate of 8000–20,000 insect species is realistic. Endemism is variably high – the more than 70 native species of butterflies and 300 species of moths exhibit endemism of only 38% (Chazeau 1993). According to the Department of Entomology at The Swedish Museum of Natural History (2003), endemism of Trichoptera is especially high – for example, all but 2 of 111 described species are endemic.

For the other land areas of the region – Vanuatu, the Solomon Islands, and Fiji – estimates of insect species diversity can be little more than ‘guestimates’, given the lack of modern survey. Robinson (1975) calculated the total number of insect species inhabiting the Fiji group of islands as in excess of 3500. This figure is to be tested, because insect biodiversity of the Fijian islands is being inventoried in detail under the National Science Foundation–Fiji Terrestrial Arthropod Survey (Brennheus and Bickel 2005).

AUSTRALASIAN INSECT BIODIVERSITY – OVERVIEW AND SPECIAL ELEMENTS

Australia

Australia, in keeping with its size as a continent occupying some 5–6% of the earth’s landmass, exhibits...
all major elements of insect biodiversity. Among the few departures from proportionality are the Isoptera (termites), with perhaps more than 10% of the global diversity; this might be so also for Phasmatoidea (stick and leaf insects). The three absent ordinal-level taxa, Gryllloblattodea, Mantophasmatodea, and Zoraptera, are geographically restricted minor orders of low species diversity, and are not present anywhere in Australasia. Strepsiptera and Embiidina, although represented in Australia, are absent from New Zealand. At the level of family, distinctive patterns emerge with some local endemics and many more restricted to the southern hemisphere ("Gondwanan").

Typical diversity patterns are shown by the aquatic orders. In Odonata, the Hemipteroidea, comprising a single charismatic species sometimes given the higher rank of Hemiptheoidea, is restricted to a few southern Australian pools (Traeman et al. 1992). The family Petaluridae, represented by Jurassic fossils, has five extant Australian species, including Petalura ingentissima, with a wingspan of up to 160 mm, making it the largest of living dragonflies. The small odonate families Hypopterygidae, Diphlebiidae, and Cordulephyidae are endemic to Australia, whereas others are widespread, of northern origin, or patchily present in other austral continents ("Gondwanan").

Early recognition of the austral relationships among the Ephemeroptera by Edmunds (1972) has been substantiated and reinforced, even as family concepts change. The family Teloganodidae (which rather unusually includes South Africa and Madagascar in its Gondwanan pattern) and many clades, including Amelotopidae, Nesamelidae, Onciagavridae, and Balldentidae, suggest austral radiation, as do the remarkably diverse Australasian Leptoblothidae (Christidis 2006). Three of four Australasian families of Plecoptera (Eustheniidae, Gripopterygidae, and Austropeltidae) belong to the monophyletic Gondwanan suborder Austropeltiaria (McClusky 2006). In the Trichoptera, the Hydrobiosidae are predominantly Australasian, and Plectrotaridae; Antipodoecidae are endemic to Australia; and Chathamiidae, Oeconesidae, and Conoesucidae are restricted to Australia and New Zealand; Kokiriidae to South America, Australia, New Zealand, and New Caledonia; Tasimiidae to Australia and South America; and Helicophlebiidae to New Caledonia, New Zealand, Australia, Chile, and South America (Wiggins 2005). Although these aquatic orders and their predominantly running-water habitats are quite well studied, only recently has novel aquatic diversity been uncovered – that of diving beetles (Dytiscidae) in underground aquifers beneath arid Australia (e.g., Humphreys 2001; Cooper et al. 2002; Ilalkie et al. 2004). This unexpectedly diverse system originated perhaps when aquatic species from temporary habitats, and from several different lineages, evaded drought by entering calcrites (the hyporheic zone in limestone areas), essentially driven under-ground by historical aridification of the continent in the Late Miocene/Early Pliocene some 5 mya (Leys et al. 2003). Many true flies (Diptera) with immature stages associated with minor aquatic habitats such as seeps or waterfalls, including the Blephariceridae (Zwick 1977, Gibson and Courtney 2007), Chromonomidae (e.g., Cranston et al. 2002), Empididae (Sinclair 2003), and Tsimbleidae (Austin et al. 2004), have diversified from Gondwanan ancestors. The Nannochoristidae, the only Mecoptera with an aquatic larva, likewise are present in streams of New Zealand, southeastern Australia, and Chile. The high-ranking hemipteran suborder Coleorrhyncha comprises only the Gondwanan family Peloritidae (mossbugs), which live among sphagnum and liverworts, especially in forests of southern beeches (Nothofagus).

Patterns of familial diversity, endemism, and regional distribution, such as those shown by these aquatic insects, are mirrored within the more terrestri-al orders (Cranston et al. 2002, Austin et al. 2004). Some strong diversifications of insects are associated with Australia’s major plant radiations; for example the Mimosaceae, including Acacia, Myrtaceae especially Eucalyptus; and to a lesser extent the Casuarinaceae. Proteaceae seem, for the main part, to have avoided insect associations. Major et al. (1997) estimated that there could be between 15,000 and 20,000 species of phytophagous insects on Eucalyptus in Australia, including members of Hemiptera (especially psylloids and coccoids), Coleoptera, Diptera, and Lepidoptera (Austin et al. 2004), but there is a conspicuous paucity of Thysanoptera (Mound et al. 2004). The Chrysomelinae (leaf beetles) demonstrate a radiation associated with eucalypts of some 750 species, but are virtually lacking on Proteaceae (C. A. M. Reid, personal communication). Notable Australian plant-associated radiations include several independent origins of gall-inducing Coccoidea (scale insects) (Cook and Guilan 2004, Guilan et al. 2005); the philarchitrid Acacia thrips (Crespi et al. 2004); the ecologically significant, lerp-forming spondylipsine Psylloidea (Hollis 2004; Taylor 2006);
the cecidomyid gall midges (Kolesnik et al. 2005) and near-endemic Fergussonimidae (Diptera) (Scheffer et al. 2004; Taylor 2004); gall-inducing Chalcidoidea (Hymenoptera) (La Salle 2004); and the several thousand (perhaps 5000) species of oreophorine moths (Oecophoridae), whose larvae consume mainly fallen myrtaceous leaves (Common 1994). Other disproportionately represented insect groups include the Phasmatodae, cicadas, and pselephine Staphylinidae. Among the social insects, the short-tongued bees (Colletinae and Halictinae) and eumenine crip wasps are strongly represented, as are the termites, especially in arid and northern Australia. Above all, the Formicidae – the ants – rule. With a described 1275 species and subspecies (Shattuck and Barnett 2001) and perhaps as many as 4000–5000 endemic species, ants dominate ecologically in all but tropical rainforests. This ant diversity and biomass, particularly in more arid Australia, is evident to any modestly observant citizen.

Relictuality, which refers to the appearance of isolated high-ranking taxa for which phylogenetic or fossil evidence exists of past wider distribution and diversity, is a notable feature of Australasian insects. Thus, the species-rich bulldog ants (subfamily Myrmicicinae), now restricted to Australia, indubitably include fossil taxa from Argentina and the Baltic (Ward and Brady 2003). Mastotermitidae, the once-diverse sister group to the remaining termites, is reduced now to Mastotermes darwiniensis, a pest in northern Australia. The biting midge family Austroconopidae, which is abundant and diverse in Lebanese and other Cretaceous-age amber, is represented now by a single species that feeds on early morning golfers in suburban Perth, Western Australia. The cicada family Tettigarcidae (the sister group to all other cicadas) is known from only two extant Australian species, although several Mesozoic northern hemisphere fossil genera are described. Many other examples suggest that the southern hemisphere, perhaps Australia especially, has served as a long-term refuge from the effects of extinctions in the northern hemisphere (Cranston and Gullan 2005; Grünwald and Engel 2005). Australia’s offshore islands support some enigmatic biodiversity, perhaps none more so than Lord Howe Island. In a report provided by the Australian Museum to NSW NP and WS in 2003, some 1800 terrestrial and freshwater invertebrate species were reported for Lord Howe Island. Additional survey has brought the Coleoptera fauna to more than 500 species, with minimally 23 species of at least 10 mm in length. Typically, for offshore islands, about half the species are flightless and many of these are probably extinct on the main island, whereas offshore islands and rocks still harbor some species. A series of observations from first surveys in 1916 (by Arthur Lea, 2 years before rats arrived), three surveys in the 1970s, and more recent ones show that extinction for many species is probable but not definite, because species such as a large flightless scarab and blaberid cockroach have been rediscovered in sites where rats have been present for many decades (C. A. M. Reid, personal communication). The Lord Howe Island wood-feeding cockroach (Panorhina laita) and stick insect (D. australis) are two of only ten insect species listed as endangered under the New South Wales Threatened Species Conservation Act.

The more remote, and far more degraded Norfolk Island only developed its fauna when regional volcanic activity ceased, probably within the last 2.1 million years (Holloway 1977). The fauna comprises endemics and a mix of derivatives with relationships to proximate areas; of the 98 species of Macroplepidoptera, 22 species and subspecies are endemic. Among the endemics, most have affinities with Australia and New Caledonia, only two with New Zealand (Holloway 1977). The single Norfolk Island endemic species of the otherwise New Zealand cicada genus Kikihia, K. convicta, apparently derives from a recent long-distance dispersal from New Zealand (Attenborough et al. 2004b). Half of the 20 species of Orthoptera on Norfolk Island have associations with Australia, the remainder with New Caledonian or Southeast Asia; three native Blattodea are known, with five introduced species especially on the degraded Phillip Island (Rentz 1988).

New Zealand

One of the strongest contrasts between insect biodiversity in New Zealand and Australia is the modest diversity and ecological insignificance of New Zealand ants – only 7 genera and 11 species of native ants (Brown 1958). That this is increasingly supplemented by invasive tramp ants, in common with so many Pacific Islands, does not alter what is, by any definition, an impoverished ant fauna, simply an attenuated subset of Australia’s ant fauna, with no high-level endemism. Biogeographic explanations
include the ecological — the generally more humid and cool climate is unfavorable — and the historic — ants failed to recolonize after major past extinction associated with submergence of the islands.

A second strong difference is the high rate of apery (winglessness) among New Zealand insects, especially those living on offshore and subantarctic islands. According to Larivière and Larochelle (2002), about 25% of the New Zealand Heteroptera fauna is flightless, with rates of 65–70% in the Aradidae and Rhyaphorochromidae. All endemic Blattodea (cockroaches) are flightless, as are many Coleoptera and Orthoptera.

An absence in New Zealand of the major Australian plant radiations means a lack of the associated diversifications that are seen in Australia. The four native species of Nothofagus, southern beeches, which often form natural monoculture forests, have a greater insect diversity than might be expected (Hutcheson et al. 1999). Nothofagus might host numerous sap-sucking insects, especially certain beech scales (Coccoidae) whose exudates provide an important food resource in temperate forest ecosystems (Moller and Tilley 1989, Sessions 2001). Minor insect radiations are associated with the podocarps, including some yponomeutid moth genera shared with Tasmania (Dugdale 1996a, McIullan 2003) and, as in Australia, many moth species develop in forest leaf litter (Dugdale 1996b). In contrast to the rather low forest insect diversity, more open habitats support endemic cicadas, orthopterans (both acridid grasshoppers and the wet open upland and offshore habitats, including tussock grasslands and scree fields (Buckley et al. 2001, Tenrick 2001, Arensburger et al. 2004b, Thinn and Gemmell 2004).

Although New Zealand’s aquatic insects belong largely to families, and often genera, that are present in Australia or New Caledonia, Chile, and Patagonia, they display high species endemism (90–99% according to Collier 1993, Harding 2003). Entomological contributions to the treatment by Najt and Grandcolas (2002) surveyed insect taxa with some diversity, but failed to find any substantial or ancient radiations, and in general Holloway’s impressions have been confirmed by studies of other groups. Thus, Murienne et al. (2005) found the diversification of ten New Caledonian species of the cockroach genus Angustinicus (Blattiidae: subfamily Tryonicinae) dated to not older than 2 million years. New Caledonia is implicated in the evolution of West Pacific cicadas in the clade Kikidina, Martsicidae, and Rhopaluda distributed among New Zealand, New Caledonia, and eastern Australia. Molecular phylogenetic studies by Arensburger et al. (2004) indicated the group originated (1) from a New Caledonian ancestor, (2) gave rise to one or several New Caledonian clades, or (3) arose from an Australian ancestor that colonized both New Zealand and New Caledonia. Whichever is correct, the divergence of New Zealand genera from the Australian and New Caledonian genera evidently took place in the last 11–12 million years (Arensburger et al. 2004a). Proposed adaptive radiations in New Caledonia, such as the micropterigid Lepidoptera (Gibs 1983) that show older, vicariant relationships between the island and New Zealand, evidently need application of molecular techniques to assess implied datings.

The numbers of phytophagous insects of New Guinea show that this geologically complex island harbors an expected high diversity such as that associated with tropical regions. Among these phytophages, the leaf-rolling weevil family Atteilidae, notably some species in the genus Euops, are associated with Nothofagus (Riedel 2001a), although with Myrtaceae in

New Caledonia, New Guinea, and Melanesia

New Caledonia is renowned for an extraordinary botanical diversity, with both relicts and radiations of several plant groups, including Araucaria and Agathis and other rare and endemic gymnosperms. To test if phytophagous insect diversity might track this plant diversity, Holloway (1999) assessed the diversity and relationships of New Caledonian Lepidoptera, especially the Macrolepidoptera. Levels of endemism were moderately high, relationships tended to be directly with proximate Australian, New Guinean, and, less often, New Zealand taxa, and species richness was lower than expected for the area (Holloway 1999). Although exhibiting a radiation, New Caledonia’s Rhytidoponera ants also appear to be derived recently from Australian relatives (Ward 1984, Lattke 2003). Entomological contributions to the treatment by Najt and Grandcolas (2002) surveyed insect taxa with some diversity, but failed to find any substantial or ancient radiations, and in general Holloway’s impressions have been confirmed by studies of other groups. Thus, Murienne et al. (2005) found the diversification of ten New Caledonian species of the cockroach genus Angustinicus (Blattiidae: subfamily Tryonicinae) dated to not older than 2 million years. New Caledonia is implicated in the evolution of West Pacific cicadas in the clade Kikidina, Martsicidae, and Rhopaluda distributed among New Zealand, New Caledonia, and eastern Australia. Molecular phylogenetic studies by Arensburger et al. (2004) indicated the group originated (1) from a New Caledonian ancestor, (2) gave rise to one or several New Caledonian clades, or (3) arose from an Australian ancestor that colonized both New Zealand and New Caledonia. Whichever is correct, the divergence of New Zealand genera from the Australian and New Caledonian genera evidently took place in the last 11–12 million years (Arensburger et al. 2004a). Proposed adaptive radiations in New Caledonia, such as the micropterigid Lepidoptera (Gibs 1983) that show older, vicariant relationships between the island and New Zealand, evidently need application of molecular techniques to assess implied datings.

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Australia (Riedel 2001b). Exceptional diversity is found in the Phasmata – with more than 200 species of phasmids in 58 different genera, comprising more than 6% of the world’s described fauna (van Herwaarden 1998), and the Odonata with more than 400 species, comprising about 10% of the global fauna (Kalkman 2006). Evolutionary biologists have uncovered a diversity of flies (Diptera) with ‘antlers’ in New Guinea and northern Australia, among which the tephritid genus Phytalmia is exceptionally endowed (McAlpine and Schneider 1978).

The Fijian insect fauna is poorly known (Fiji Department of the Environment 1997), but in keeping with its oceanic location, it evidently has a fraction of the megadiversity of New Guinea. Robinson (1975) surveyed the Lepidoptera and estimated 600 species of Microlepidoptera and 400 of Macrolepidoptera. In the absence of an explicit phylogeny, it is unclear if the estimation of seven endemic genera, with modest radiation (although high for a Pacific Island), and several other intrinsic radiations is correct. An estimated 88 ant species from Fiji (Wilson and Hunt 1967) is an underestimate, with some 180 species likely including 30 exotics (E. Sarnat, personal communication). Of 13 species of Odonata recorded from Fiji, 22 (67%) were endemic (Tillyard 1924). Macrolepidoptera, cicadas, dolichopodid flies, and some beetle families show relationships with New Guinea, but several unexpected relationships link Fiji with the New World (Evenhuis and Bickel 2005).

Vanuatu seems to have many single species representatives of genera that are otherwise widely distributed in the Asia-Pacific Region, although some modest Miocene-dated radiations in platynine Carabidae have been identified (Lieberherr 2005). This finding of a platynine radiation is supported by Hamilton’s (1981) study of the endemic aphrophorine Cer copidae (Hemiptera), but no other such radiations have been documented. Although 105 of the 364 recorded Vanuatuan species of Macrolepidoptera are endemic, Robinson (1975) believed that none had its closest relatives in this Archipelago.

**THREATENING PROCESSES TO AUSTRALASIAN INSECT BIODIVERSITY**

The processes threatening insect biodiversity vary somewhat across and within Australasia, but there are several unifying causes. These are habitat loss, introduced animals including invasive ants, potential effects of climate change, and a minor possibility of overexploitation.

**Land clearance and alteration**

Clearance of native vegetation, including deforestation, remains the single most significant threat to all terrestrial biodiversity. Worldwide, only four countries exceed the ongoing rate of clearance of native vegetation in Australia (Williams et al. 2001). Rates of deforestation in New Zealand now are low, an inevitable consequence, given an estimated 80% loss of forest cover since human settlement. Forest loss in New Guinea, the Solomons, and Fiji continues, driven by demand from developed countries and weak central controls over logging permits and exports, and revenue collection (FAO 2000). In New Guinea, and throughout Melanesia (the Solomons, Bismarck Archipelago, and Vanuatu), Polhemus et al. (2004) have documented freshwater biotas threatened by alteration of aquatic environments by logging, as well as mining and rapid human population growth. Effects of these activities on all regional freshwater insects include loss of shading by riparian vegetation, leading to elevated water temperatures, increased sedimentation and nutrient inputs, and more variable flows, including increased susceptibility to drought and flood. These modifications all lead to loss of native biodiversity, increased abundance and biomass of tolerant, sometimes alien, species, and growth of algae and often nonnative macrophytes. Replacement of native woody debris in streams with alien woody debris, such as from pines in Australian afforestation programs, has detrimental biodiversity effects, even as a riparian structure is retained (McKie and Crampton 1998). New Zealand’s deforestation appears to have caused diminished taxonomic richness, range restriction, and likely extinction of certain stream insects, as assessed at
the nearly denuded, but endemism-rich Banks Peninsu-
la (Harding 2003).

Conversion of native forests and pastures to
impoverished agroecosystems dominated by alien
animal grazes results in the loss of native insect
biodiversity. In this context, the day-flying castniid sun
moths (Synemon plana) have been invoked as flagship
or umbrella insects (e.g., New 1997, Douglas 2004)
for Australia’s ever-diminishing native temperate
grasslands, which are among its most threatened
ecosystems (Specht 1981). In subtropical and tropical
Australian grasslands and savanna, threats to
biodiversity include overgrazing by stock of native
vegetation, especially in drought, and, controversially,
land management by fire in simulations of putative

Introduced animals

The sad history of the effects on native biodiversity of
introduced animals, such as rats, goats, mongooses,
rabbits, rats, and many others, especially on islands,
is well known (e.g., Atkinson 1989). However, much
documentation (and inference) relate to extinction
or threats to native vertebrates, perhaps especially to
ground-nesting birds. Only more recently has predator
pressure on invertebrates (whether charismatic or
not) reached the attention of conservationists and a
wider public. Experimental enclosure, or removal, of
vertebrate pests, shows that not only birds and lizards,
but also large, flightless insects such as New Zealand’s
wetas and regional stick insects, including the Lord
Howe stick (on the vertiginous Balls Pyramid), can
survive, even thrive, in the absence of four-footed ver-
min. That feral animals have caused extinction is hard
to verify, but can be surmised by evidence such as the
loss of the 15-cm wingspan Buller’s moth (Aoraias matri)
seen last by Sir Walter Buller in the New Zealand’s
Ruahine Ranges 120 years ago (while he hunted huia
birds) (Meads 1990). Examination of fossil coleopteran
diversions in the Tasman (Close et al. 1978, Fox 1978)
ing. The rain of Australian insects that descends on
New Zealand after appropriate meteorological condi-
tions in the Tahitian (Close et al. 1978, Fox 1978)
evitably leads to some establishment, including of phy-
tophages on forestry plantation Eucalyptus (Withers
2001).

Alien ants, none of which are native to Australasia,
are among the worst of invasive animals. They
create an insidious problem worldwide that threatens
insect biodiversity, especially on Pacific Islands
where existing disturbance has predisposed habitat
to invasion (McClynn 1999, Le Breton et al. 2005).
On New Caledonia, the lethal effect of Wasmannia
auropunctata on the native forest-ant fauna was
observed in invaded plots, where this New World
invasive species of ants represented more than 92%
of all pitfall-trapped ants (Le Breton et al. 2005).

Although the effects of introduced vertebrates are
visible and well-documented disasters for biodiversity,
a more insidious, but as serious a threat comes from
the ever-expanding distribution of invasive insects.
How numerous are the introduced insects can
be gauged by data from New Zealand, the coun-
try with the greatest awareness and best monitoring
systems for these threats. Thus, at the millennium,
exotic insects included 229 beetles among nearly 1000
species sampled in and around suburban Auckland, 66
thrips in a total fauna of 119 species, and some 100
argued that, by extrapolation, there must be more
than 2500 adventives, comprising about 13% of the
New Zealand insect fauna. The point Emerson (2000)
was making – that only 2.5% of these adventives were
introduced for biological control purposes, with less
than 1% comprising host-specific, carefully screened
insect species released and established for biological
control of weeds – is important, but the numbers of
exotic insects are quite staggering and are still increas-
ing. The rain of Australian insects that descends on
New Zealand after appropriate meteorological condi-
tions in the Tasman (Close et al. 1978, Fox 1978)
evitably leads to some establishment, including of phy-
tophages on forestry plantation Eucalyptus (Withers
2001).

Alien ants, none of which are native to Australasia,
Solenopsis invicta
Pheidole megacephala
including the Australasian Region as an invasive ant fauna, such observations can be repeated throughout the Australasian Region as an invasive ant fauna, such as when *S. invicta* was discovered in suburban and industrial Brisbane, Australia, in 2001 (Vanderwoude et al. 2004). The species had probably been present undetected for several years already, stemming from two separate breaches of quarantine (Henshaw et al. 2005). With predictions of rapid spread across the continent (Scanlan and Vanderwoude 2006), a massive plan to eradicate the species was quickly put in place as the state (Queensland) and federal governments recognized and listed the presence of the red imported fire ant as a key threatening process to biodiversity. Through intensive baiting with methoprene and piriproxyfen, coupled with a massive public awareness campaign, a 99% reduction had been attained by 2004. Costs for a 6-year program were Aus$175 million, with a cost-benefit analysis showing potential costs over 30 years of non-eradication ofAus$8.9 billion. Other introduced insects that threaten native biodiversity include honey bees (*Apis mellifera*), the large earth bumblebee (*Bombus terrestris*), European wasps (Vespula spp.), and the Asian and Australian paper wasps (*Polistes chinensis* and *P. humilis*). Honey bees take over hollows in trees for nesting and compete with native animals, including native bees, for floral resources (Goulson 2003), leading to their presence and activities being recognized as a key threatening process in NSW NP and WS, Australia (NSW NP and WS 2004). Recognition of *B. terrestris* as threatening stems from its role as a pollinator of many environmental weeds and a potential disruptor of native plant pollination, based on experiences in Tasmania and New Zealand (NSW NP and WS 2004).

In New Zealand, wasps pose a major problem: *P. humilis* became abundant in Northland in the 1880s and remains in the north. German wasps (*Vespa germanica*) arrived in the 1940s and spread to the South Island 10 years later; *V. vulgaris* became established in the 1970s, and both are now widespread. The most recent arrival, the Asian paper wasp (*P. chinensis*), was found first near Auckland in 1979, and is rapidly extending its range southward. Problems with effects of wasps on native biodiversity are particularly significant in the Nothofagus beech forests where abundant honey-dew, produced by endemic coccoids (Coelostomididae), provides an abundant source of carbohydrate. This resource, on which a community of honeydew-feeding native birds once thrived, has been hijacked by *Vespula*, particularly *V. vulgaris*. Extraordinary wasp densities of 10,000 workers ha\(^{-1}\) and peak biomass of 5.8 kg ha\(^{-1}\) can develop by the late summer (Beggs 2001). Wasp demand for protein is nearly insatiable, such that for many invertebrate prey items, such as caterpillars, individual survivorship probability is near zero (Beggs and Rees 1999). Wasp densities need to be reduced by an estimated 80–90% to conserve vulnerable native species, but even mass baiting with the effective fipronil and the introduction of an ichneumonid wasp parasitoid is unlikely to sustain such high levels of control (Beggs 2003). Asian paper wasps in warm and humid northern New Zealand can develop densities of more than 6,500 wasps and 200 nests ha\(^{-1}\) and consume 1 kg ha\(^{-1}\) of invertebrate biomass per season, giving rise to fears of severe effects on native ecosystems (Chapman 1999). Control of this species is even more difficult than for *Vespula* because nests are difficult to find due to location in dense bush and infrequent traffic of wasp residents, and numbers of wasps are reduced only minimally by baiting and trapping (Toft and Harris 2004).

**Climate change**

The history of the globe involves cyclical climate change, some of which has been induced by volcanism and solar cycles, interspersed with episodic holocene impacts. The planet is recovering still from the effects of the Pleistocene glaciations of much of the mid-high latitudes of the northern hemisphere. In Australia, the Holocene period has seen reduced temperatures and...
increased aridity, although any linkage to northern climate variations remains unverified (Turney et al. 2006). Nonetheless, Australian Holocene climate changes affected vegetation (with increased xeric conditions producing rainforest contraction and assisting spread of sclerophyllous, Eucalyptus-dominated vegetation). The insect biota was affected too, as distributions shifted in latitude and elevation with changing temperatures (Porch and Elias 2000) (Coleoptera), Diptera and Cranston 2001 (Chironomidae). In New Zealand, the same organisms also show historical changes (Marra et al. 2004, 2006, Woodward and Shulmeister 2007), although the causes and synchronicity might be dissimilar to those in Australia (Allaway et al. 2007), as they relate mostly to extensive volcanism in New Zealand. In both Australia and New Zealand, El Niño-Southern Oscillation (ENSO) events have been important in the past and remain influential. Despite this background variability, the Australian government (a notable non-signatory to the Kyoto Convention at November 2007) accepted that alteration to Australia’s climate already occurs over and above natural variability (DEH 2004). Changes such as long-term spatial and temporal variation in rainfall and temperature patterns are expected to influence Australia’s biological diversity (DBH 2004). A widely accepted scenario of 3°C warming by 2050–2100, for example, compared with a 1990 baseline (IPCC 2001, Hughes 2003), means that species with latitudinal ranges of less than about 300 km or with an elevation range less than about 300 m will dissociate totally from their present-day temperature envelopes (Westoby and Burgman 2006). In other words, their present-day distributions could not be maintained. Federal acceptance of the scientific consensus concerning such expected effects on species (and ecosystems) under future climate scenarios came from a growing list of changes consistent with predictions. Inevitably, perhaps because of their ectothermy, some of these changes involve insects.

As in the northern hemisphere, the extensive databases for butterfly locations and flight dates have provided a foundation against which changes can be assessed. Using bioclimatic modeling for 77 species of Australian butterflies, Beaumont and Hughes (2002) showed that, although few species had narrow climatic ranges (<1°C), a major of species were predicted to suffer range losses, some substantial. Under extreme scenarios, narrow-range endemics would lose their total ranges, especially vulnerable would be those species that depended on mutualisms such as ant attendance and food-plant specificity. Even potential beneficiaries, such as a pair of Western Australian species whose modeled suitable habitat was predicted to expand to include South Australia, still would have to cross 1000 km of an inhospitable Nullabor to make the necessary range extension. Evidently, specialists are in trouble under climate change, as predicted for Acacia-feeding beetles (Andrews and Hughes 2004) and high-elevation dipterans (Wilson et al. 2007). Species unable to track their changing climate envelopes, due to low dispersivity, including aptery (Yeates et al. 2002), small population sizes, or loss of their host or habitat (e.g., insufficent altitude) will go extinct. Adding to the problem is the fragmentation of the landscape, in which a potentially suitable environmental envelope might be entirely unavailable through anthropogenic conversion. In New Zealand, we can imagine that glacier-associated insects will lose their habitat. Current glacial retreat is one of the clearest indicators of climate change affecting the New Zealand environment. For example, the Franz Joseph glacier has retreated 1500 m since scientific observations began in 1860. The Franz Joseph, Fox, and other glaciers are in an overall pattern of retreat, despite some fluctuations and short-term advances, which is expected to continue and threaten cold-stenothermic insects.

As a perhaps terminal insult, we can reasonably assume that climate change increases the risk to biodiversity from invasive species, in that broad-ranging taxa are potentially invasive and least affected by climate change.

**AUSTRALASIAN BIODIVERSITY CONSERVATION**

In comparison to the northern hemisphere, insect biodiversity conservation was somewhat late to attain recognition in Australia. Key’s (1978) report to the Australian National Parks and Wildlife Service on the conservation status of the nation’s insects pioneered in drawing attention to issues of land degradation and its effects on the endemic insect fauna. New’s Insect Conservation: an Australian Perspective (1984) was influential in furthering awareness, and he has continued to play a leadership role in promoting insect conservation globally (e.g., New et al. 1995, New 1997). Penny Greenslade has been an indefatigable advocate for the
inclusion of insects in conservation planning, especially concerning listing of species, in collating invertebrate data on Australia’s offshore responsibilities, and in stimulating a conservation ethos in the national entomological society. The review by Greenslade and New (1991), which remains an excellent, far-sighted overview of Australian insect conservation, drew the attention of one of the largest meetings of insect conservationists ever held at that time, the 15th Symposium of the Royal Entomological Society, London, 1989 (Collins and Thomas 1993). Because such meetings indicate the depth of interest in the field, the holding of invertebrate biodiversity and conservation meetings in Australia since the early 1990s is indicative of a wide and growing regional interest. The proceedings of each meeting (Ingram et al. 1994, Yen and New 1997, Ponder and Lumney 1999, Austin et al. 2003) demonstrate ‘progressively greater awareness and concern for a great variety of taxonomic groups at scientific, legislative, economic and social levels, and approaches to practical appraisal and management’ (New and Sands 2004: p. 218).

Butterflies always have been best known in terms of their taxonomy (with some 650 or so Australian species and subspecies), distributions, life histories, and threats to their existence (New 1990, 1999; Dunn et al. 1994, Sands 1999) – and this remains so today with a range of conservation action and recovery plans in place (e.g., Sands et al. 1997; O’Dwyer and Attiwill 2000, Sands and New 2002). Models of such processes can be seen in the endangered species listing and development of action plans for the Bathurst copper (Paralucia spinifera) and the ongoing management plans for the Etham copper (P. pyrodous hinds) in Victoria (New and Sands 2004).

In New Zealand, too, assessment of risk to insects often starts with Lepidoptera. Thus, using a suite of evaluation criteria, Patrick and Dugdale (2000) assessed the conservation status for New Zealand’s 1685 species of Lepidoptera. Category A (highest priority) threatened species numbered 42 species, with 29 in urgent need of conservation action. Category B (second priority) numbered 42 species, and Category C (third priority) 20 species; another 102 species were regarded as being at risk. Previously, only two lepidopteran species, Asphodelus striaria and Xanthorhoe bullata, had been listed in Category A. Most of the endangered species are phytophagous as larvae; the more numerous detritivores appear less threatened. Most at-risk Lepidoptera are members of natural shrub–grassland communities, and are concentrated geographically in Canterbury and Otago where such habitats are more prevalent.

Despite the butterfly-centric bias in insect conservation, an increasing range of taxa are recognized as being of conservation concern, able to arouse a wider concern for environmental conservation and to act as flagships for endangered ecosystems. In New Zealand, some rarer species of weevils have attained such status (e.g., Sherley and Hayes 1991, McGuinness 2003). Concern for the phylogenetically distinct odonate Hemiargia spinifera led to assessment of the conservation status for New Zealand’s aquatic insects, including large charasmatic odonates and restricted-range Plecoptera and torrent midges (Ephemeroptera), all featured early in the Australian listings for conservation concern.

As is widely recognized, legislative actions concerning conservation, although sometimes bureaucratic and always time consuming, are essential for public education, demonstration of institutional commitment, and putting in place enforceable and long-term protection. This is the interface between conservation science and its application. At the international level, Australasian nations all were early signatories of the Convention on Biological Diversity (CBD), in mid-1992, with ratifications made before the end of 1993. In keeping with the obligations associated with the convention, each country has produced plans for conservation. Australia’s National Strategy for the Conservation of Australia’s Biological Diversity (DEEWR 1996) is typical in integrating biodiversity conservation with natural resource management, sustainability, identification, and management of threatening processes, combined with advocacy of enhanced research, education, and documentation. The issue of how one can conserve biodiversity on a continental scale without understanding what is present was addressed through a strengthened role for the Australian Biological Resources Study (ABRS), the major funding source for biodiversity inventory work, although a decade later any enhanced role remains too modest for the taxonomic task in hand (Yeates et al. 2001).

Australia’s biodiversity strategy led directly or indirectly to some novel approaches concerning invertebrates in biodiversity conservation that are of global relevance. These approaches include efforts to integrate phylogeny into conservation measures (e.g., Faith 2002, exemplified by Faith et al. 2004), the development of modeling tools for conservation-site selection (e.g., Ferrier et al. 1999), and a veritable...

New Zealand’s biodiversity strategy (DoC 2000) seeks to halt the decline in New Zealand’s indigenous biodiversity, noting especially the loss of around 80% of native forest cover and 90% of wetlands. Programs include those to incorporate Maori knowledge and enhance their understanding and involvement in biodiversity conservation. The strategy gives a high profile to the biodiversity threats posed by invasive species; the country is a world leader in the field of invasive species research as a result of its experience with a host of plant and animal pests and its concern with quarantine (Biosecurity) and the maintenance of a healthy environment. With this background, New Zealand was an obvious host for the IUCN Invasive Species Specialist Group (ISSG) of the World Conservation Union. ISSG offers practical advice and aid to smaller biodiverse island nations to eliminate aliens (such as cane toads, cats, and rats), notably through the collaborative Pacific Invasives Initiative.

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