Chapter 5
Conservation Needs and Early Concerns

5.1 Summarising the Scenario: An Initial Perspective

The general and urgent need for conservation of *O. richmondia* devolves largely on the losses of rainforests in the region, a process that has had severe impacts on many native animals and plants, and for which the Richmond birdwing has become a notable flagship species to publicise the less heralded plight of many other invertebrates, and also some of the basic principles of landscape ecology and the critical specialised needs of interdependences between species in communities. Whilst loss of lowland rainforests of subtropical eastern Australia, and the food plant vine *P. praevenosa* are regarded as principal threats to the Richmond birdwing, the implications of those losses are very broad, despite notional formal protection of the communities. As emphasised earlier, suitable forest areas are now highly fragmented. In Queensland, this type of lowland rainforest survives only as fragments near the coast along Kin Kin Creek, east of Pomona, near Caloundra, and at Burleigh Heads National Park. Lower sub-coastal birdwing habitats are further inland on ridges and low valleys of the Blackall, Conondale and D'Aguilar Ranges, at Mount Tamborine, and NSW Border Ranges. In NSW there are coastal birdwing habitats in national parks, patchily distributed from the Tweed River, Byron Bay and Broken Head National Parks on the coast, and on Mount Warning and further inland near Mallanganee, near the Richmond Range. Although the vine was previously known in the area, it is not known if there are any rainforests where *P. praevenosa* is currently present in the Clarence River Catchment, where almost all riparian rainforest was cleared for grazing cattle in the late 1800s and early 1900s. The conservation status of *P. praevenosa* has been evaluated by the State Government, to be 'lower risk' in Queensland while the vine is not considered to have conservation significance in New South Wales.

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In Queensland and New South Wales, several categories of lowland rainforest were considered formally by the Australian Government (EPBC Act 1999) to be threatened and have been classified according to the plant communities they support, under the banner of Lowland Rainforests of Subtropical Australia (p. 81). However, these lowland subtropical rainforest remnants and the fauna they support continue to be threatened with extinction from clearing, mining for road base, invasion by weeds and human disturbance. Some endemic fauna and flora are now threatened by drought associated with climate change. The rainforests depend on rich volcanic soils or alluvial soils of volcanic origin with annual rainfall of around 1,300 mm and, together with the lower moist ranges, are the habitats for a number of subtropical insects, including the Richmond birdwing, the southern pink underwing moth (*Phyllodes imperialis smithersi* Sands) occupying the same type of habitat (Sands 2012), and several other butterflies, for example, the rare lycaenids *Pseudodipsas cephenes* Hewitson and *Hypochrysops miskini* (Waterhouse). Many such species are at the southern edge of their ranges and their distributions are confined to the southern coastal pockets of rainforest, clearly separated from northern populations by the dry coastal 'barrier', between Mackay and Rockhampton and some species having distinctive morphological or biological characteristics. These small butterflies are good examples of other subtropical rainforest species threatened with extinction from invasive introduced animals and weeds.

5.2 Threats

The most serious threats to the Richmond birdwing have been destruction and disturbance of rainforest habitats that support its lowland food plant, in subtropical eastern Australia. The butterfly's range contraction between about 1950 and 1990 is an important indicator for the impacts of these threats. These are closely followed in importance by the rising impacts on the food plant from prolonged drought and invasive exotic weeds, and fragmentation of existing habitats leading to inbreeding depression. Major needs for conservation of the Richmond birdwing were recognised long ago, and were assembled under the Draft Recovery Plan in 1996 (p. 112). They include: (1) preservation of remnants of subtropical rainforest, and planned restoration of others; (2) progressive eradication of the alien *Aristolochia elegans* wherever it occurs, and discouraging any further plantings or expansion: (3) propagation and planting of *Pararistolochia praevenosa*, to enhance and extend its presence throughout the butterfly's historical range; whilst (4) undertaking further biological research, for example on the food plant pollinators, is needed to enable the birdwing and its food plant to achieve a reduced level of conservation need.

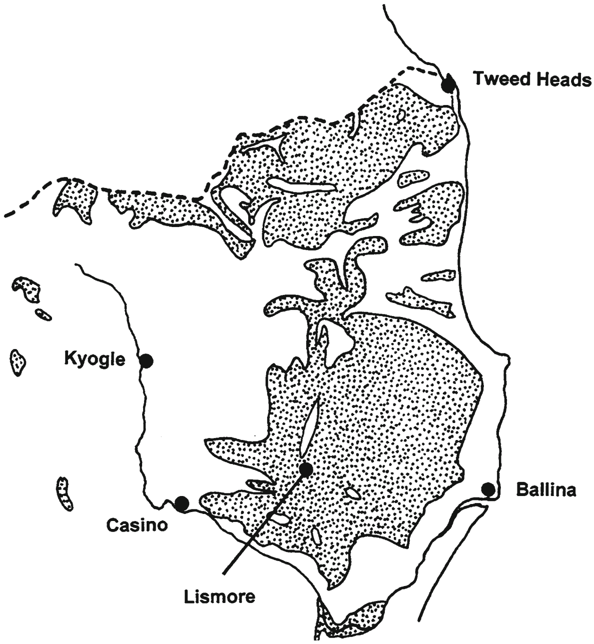
The wax scale insect *Ceroplastes ceriferus* (Fabricius) has been observed infesting the stems and exposed roots of *P. praevenosa* but it is usually maintained at low levels by a complex of natural enemies (Waterhouse and Sands 2001).

The major threats are discussed separately below.

5.2.1 History of Rainforest Destruction

A wide area of north-eastern New South Wales once supported extensive subtropical lowland rainforest (Fig. 5.1), and the extent of its loss is illustrated well by the decline of the 'Big Scrub' area to the east of Lismore. This major biotope formerly extended over some 75,000 ha (Fig. 5.2), but from the 1840s on was cleared extensively to leave only remnants by the end of the nineteenth century. By the early 1990s, only approximately 556 ha of extensively fragmented rainforest remained (Lott and Duggin 1993). The lowland topography rendered much of the area amenable to clearing for agricultural conversion, with dairying widespread in the initial decades following widespread timber extraction (predominantly for the Australian red cedar, *Toona australis*). More recent impacts include diversified cropping, including fruit crops such as avocado and macadamia nuts, excessive removal of healthy stream flows by pumping, and extended urbanisation around towns. Remnant forest patches are recognised as important for biodiversity, and support significant numbers of rare plant and vertebrate species but, unfortunately, these rainforest habitats have been, and continue to be destroyed for farming, clearing, road works or urbanisation. Information on invertebrates of the Big Scrub is relatively scarce, but more concerted information on those of the more southerly Manning Catchment forests of New South Wales gives some flavour for the enormous variety likely to be present (Williams 1993). The Manning Catchment is beyond the range of both *O. richmondia* and its food plant. However, despite increasing pressures, many of the Big Scrub remnants have not decreased in size over the last half century, and some are now the focus of active restoration and replanting programmes as a trend of wide general conservation importance across the region. Declines in broad-scale farming have enabled some natural regeneration, but also led to increases in weed infestations, with weed control also an important and rising conservation need. Restoration work on the Big Scrub has been pursued actively for many years, and substantial progress has been made with revegetation targeted to expand and progressively link the various fragments. The Big Scrub Rainforest Landcare Group (more recently 'Big Scrub Landcare') was founded in 1992 and has been the key driving force behind this long term programme. Its activities now span both practical work and conservation advocacy, with an impressive record of fund raising and cooperations. Substantial weed control programmes are involved, and 'The landscape is increasingly containing elements of the original rainforest within a mosaic of production horticulture.' (Parkes et al. 2012, p. 219).

Fig. 5.1 Former extent of subtropical rainforest (shaded) in New South Wales (Based on Floyd 1990)



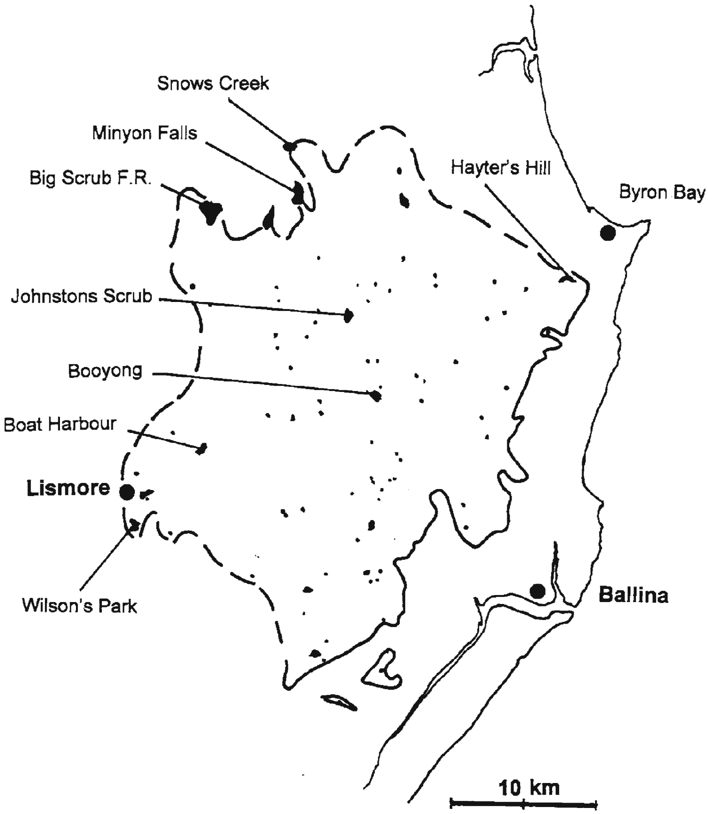


Fig. 5.2 Loss of forest in New South Wales: the area of the 'Big Scrub', showing extent of remaining fragments within former forested areas (After Lott and Duggin 1993)

The largest remnants are the Big Scrub Flora Reserve (148 ha), and Minyon Falls (68 ha), whilst many others are less than 3 ha; the sizes of many have been increased for clarity in Fig. 5.2. Long-term viability of the largest remnants appears good, because these are sufficiently large to retain a relatively intact rainforest core, and also abut extensive eucalypt forests. These are regarded as sites of the highest conservation significance. Lott and Duggan (1993) recommended establishing regrowth corridors helping to link remnants of the Big Scrub, and noted that 'Remnants should be expanded by direct planting of rainforest species on the surrounding lands, by connecting remnants with planted corridors and/or improvement of the regrowth corridors by weed removal and rainforest plantings'. This principle of promoting fragment connectivity is central to the birdwing conservation programme.

5.2.2 Prolonged Drought and Floods

Prolonged periods of drought since the mid 1980s, accompanying climate change, have had major impacts on the survival of the immature stages, with abnormally high temperatures and low humidities resulting in desiccation of the living eggs, larvae and pupae. For example, on several occasions between 1994 and 1996, and 2001 and 2007 in south-eastern Queensland, eggs thought to be healthy failed to hatch, some pupae developed black markings before becoming desiccated, and cessation of pupal diapause followed by adult eclosion became unusually protracted. More recently in spring of 2012, lack of rainfall may have been responsible for abnormal adult eclosion. Eggs failing to hatch may have also resulted from eggs deposited by unmated females.

A major impact from prolonged drought is that it leads to toughening of leaves of the food plant, those leaves then becoming inedible by freshly-eclosed first instar larvae. Toughening of leaves is a drought-resistance strategy, and accompanied by declines in nutrient (mostly nitrogen) concentrations occurs when the vines are stressed. It is possible that temperature extremes may enhance responses of microsporidia that could be benign under normal climatic conditions but become pathogenic when stressed by drought, an effect known in other Lepidoptera. However, no evidence of spores of microsporidia have been found in several dead and discoloured pupae. Prolonged drought can result in death of wild food plant vines, as seen in several protected areas (for example, Burleigh Heads National Park) during the dry periods that affected much of eastern Australia from 1995 to 2009. Again in August and September 2012, absence of rainfall near Brisbane caused otherwise healthy vines to die unless hand watering was maintained. Prolonged drought has had the most serious impacts on both species of food plant vines, whether the vines were wild or planted, and it continues to be a serious threatening process associated with climate change in south-eastern Australia. At higher elevations (>600 m), prolonged drought in 1995–1996 was thought to be responsible for disappearance of all stages of the Richmond birdwing in areas where they had been previously been breeding on *P. laheyana* (Sands and Scott 1996). There is little doubt that climate change, accompanied by increasing drought events, disrupts pupal diapause and reduces the production of soft and palatable leaves of the larval food plant, and will become a serious and increasing threat in future decades.

Floods, also associated with climatic extremes, caused many losses of the vines in 2010 when vast areas of otherwise healthy riparian rainforests became inundated, killing the plants sensitive to lack of drainage and sweeping away many vines growing on, or planted on, embankments. The root system of *P. praevenosa* is fragile and the soils are easily undermined. The rhizomes do not penetrate deeply from surface soils into sub-soils. On older vines with more extensive rhizomes portions have been swept away by floodwaters, leaving the exposed sections on the surface where they readily desiccate. Flooding has commonly undermined the trees supporting old growth vines, resulting in masses of *P. praevenosa* and other companion species collapsing into heaps that usually fail to re-grow. During the floods that affected the Brisbane River a number of planted vines were probably killed by salt water or other dissolved materials.

5.2.3 Corridor Fragmentation

Fragmentation of habitats and loss of corridors, particularly when due to expanding urban development, have been implied to lead to inbreeding depression and extirpations. Corridors normally support dispersing butterflies, allowing them to move between habitats, or provide stepping stones that potentially facilitate genetic interchange between populations. Loss of corridors can lead to the losses of isolated populations for the butterflies even if the food plants are able to persist. Sites with low densities of vines are susceptible to frequent extirpations of the birdwing when the vines are not producing sufficient young leaves to support the larvae. This has been observed in natural situations where the numbers of vines are low, for example in the northern parts of the range, where the ‘rarity’ of the vines can usually be associated with the low level of nutrients failing to support this nutrient-demanding vine.

Adult dispersal is important also in considering the incidence of temporary mountain populations (Chap. 2). Rarely can the pupae of the Richmond birdwing survive the climates at high elevations (>600 m) even though these areas are suitable for growth of *P. laheyana.* From limited observations, pupae will die in July and August most years unless the winters are unusually mild and moist. While the Richmond birdwing frequently visits the higher locations on the Queensland-NSW Border Ranges, and there is ample presence of food plant vines, the offspring from ovipositing females rarely survive. An example of winter survival of pupae producing adults on the Ranges (above 600 m) was monitored in 1994 (p. 39) (Sands and Scott 2002) and earlier observations were known. It is always possible that the higher altitude population will appear more frequently under the influence of increasing temperatures, but if winter periods of prolonged drought and very low temperatures continue to occur it is unlikely that pupae will undergo changed survival rates at these elevations.

5.2.4 Natural Mortality

As well as in subtropical regions, *Pararistolochia praevenosa* also occurs near Lake Eacham on the Atherton Tablelands in northern Queensland, where the Richmond birdwing is replaced by the Cairns birdwing (*O. euphorion*). While there is a range of potential natural enemies of birdwings in their tropical habitats, none has been known to lead to extinctions or destabilise birdwing populations. Addressing the causes of natural mortality of the butterfly and vine, and how (and if) these have changed to become increased threats, is difficult but occasionally the threats can be alleviated in areas where intensive management is practiced. For example, protecting young vines with wire guards from being dug up by brush turkeys is a useful method for reducing mortality of planted vines. Although the brush turkey plays an essential part in the life cycle of the vine by dispersing the seeds, in bush regeneration areas and gardens this megapode has become very common and has often become a destroyer of the vines, digging them up wherever they have been planted, in its search for invertebrate food in the moist soils maintained to keep the vines healthy. This behaviour, also noted in the wild, confirms the strong attraction of the bird to all parts of the vine but it appears to be a major mortality factor for young seedlings and could be responsible for the ‘thinning out’ of seedlings that are often seen germinating in groups but rarely growing on to produce more than one or two undisturbed plants.

5.2.5 Collecting Specimens

There is no evidence that collecting of specimens has been a threat to the Richmond birdwing, or to either food plant, despite suggestions that this practice has influenced conservation status of the butterfly and lowland food plant. When the few specialist collectors were asked why they rarely keep more than one or two specimens of the Richmond birdwing, several reported that ‘the specimens take up too much cabinet space.’! The generalist collectors tend to take male specimens and keep in their collections specimens of the two larger, but otherwise similar birdwings, Cairns Birdwing (*O. euphorion*) and the Cape York birdwing (*O. priamus* ssp.). A risk might indeed occur if specimens are taken from isolated colonies where lowering of numbers might lead to inbreeding depression but the chances of capturing, and detrimentally reducing the numbers of such a high-flying species, are not likely to have an impact on the integrity of populations. Commercial exploitation or trade in specimens has not been a problem and the few breeders of the Richmond birdwing rear the specimens from immature stages – usually eggs or larvae – in order to obtain perfect specimens for trade. Unlike Queen Alexandra's birdwing from Papua New Guinea which has conspicuous brown and gold pupae, the pupae of the Richmond birdwing are very difficult to locate in the wild by would-be collectors. The green pupae are always well camouflaged where they are attached beneath leaves and the pupation sites chosen by the larvae are often some distance from the food plant. Whilst indiscriminate collecting should not be condoned, it is not at present considered a significant threat to *O. richmondia*.

5.2.6 Invasive Woody Weeds and Grasses

A number of exotic weeds threaten the Richmond birdwing and its lowland food plant by displacing whole plant communities, competing with any regenerating growth for light and soil moisture, and can smother the growth of seedlings. These plants are mostly garden escapes and some, for example varieties of lantana (*Lantana camara* L.), have been spreading into natural bushlands for more than 100 years. This woody shrub is very competitive after clearing, burning and forestry disturbance, particularly in riparian situations. In addition, several exotic trees are invading subtropical rainforest habitats, including a Chinese Elm (*Celtis sinensis* Pers.), the Asian Camphor laurel (*Cinnamomum camphora* (l.) J. Presl.), the South American Tipuana (*Tipuana tipu* [Benth.] Kuntz) and two privets (*Ligustrum sinense* Lour. and *L. lucidum* W.T. Aiton). All prefer moist soils with high water tables and the majority can develop competitive mono-stands and thickets. Other woody weeds of significance include the large shrubs, Indian Hawthorn (*Rhaphiolepis indica* (l.) Lindl. ex Ker Gawl.) and Ochna (*Ochna serrulata* (Hochst.) Walp.). Both continue to be widely cultivated and have proven to be competitive displacers of native vegetation in riparian vegetation. A rising threat for many native forests is the rapid spread into native forests by exotic *Pinus* spp., and the ability of the trees to displace rainforest trees and change the natural soil structures and chemistry. Stands developing from seedlings at the edge of softwood plantations form dense growth at roadsides and spread into nearby moist forests and riparian rainforests, particularly near embankments of streams where *P. praevenosa* becomes rapidly overwhelmed and the understorey native vegetation becomes sterilized. Regrettably, most conservation agencies in Australia have not appropriately recognized the threat of such weeds to native biodiversity and no action has being taken in Queensland to control the escape of pines from forestry areas. With increasing temperatures and the impacts of prolonged drought, problems from invasive weeds in subtropical forests seem destined to increase.

Several exotic vines threaten *P. praevenosa* and other native vines by competition for light, while some cut off sap flow by the constricting twining stems. A vine with tendrils, Cat's Claw Creeper (*Macfadyena unguis-cati* (L.) A. Gentry), can kill support trees, while vines with reproducing aerial bulbous stems, for example Madeira Vine (*Anredera cordifolia* (Ten.) Steenis) or those with branching underground rhizomes including Morning Glory (*Ipomoea indica* (Burm. f.) Merr) and *I. purpurea* L. (Roth.) and Mile-a-Minute (*Ipomoea cairica* Sweet), can disrupt soils and kill the root systems, while above ground they can overwhelm the foliage. Balloon Vine (*Cardiospermum grandiflorum* Sweet) is particularly well adapted to riparian vegetation and threatens the most favoured habitats of *P. praevenosa,* as does climbing asparagus fern (*Asparagus setaceous* (Kunth) Jessop), currently a less invasive species.

Unfortunately *P. praevenosa* has on occasions been misidentified as an invasive weed when the exotic undergrowth invading bushland is being cleared. With several exotic vines now invading natural rainforest there is a tendency for land managers to poison or slash vines indiscriminately and to encourage vine-free undergrowth or canopies that are free of vines, regardless of whether they are detrimental to growth of native trees and shrubs. Increasing in importance are the invasive vine 'glycine' (*Neonotonia wightii* (Wight & Arn,) J.A. Lackey), that has become a strangler of native vines and small trees, and the Singapore Daisy (*Sphagneticola trilobata* (L.) Pruski), a ground cover plant well adapted to invading the moist understorey of rainforest, where it can out-compete the low growth of most native plants, including seedlings of *P. praevenosa*. Both species are also capable of displacing the plants on compost-based breeding sites used by the pollinators of the vine.

Several invasive exotic grasses have become well adapted to moving from pastures into rainforests and becoming very competitive and will displace native vegetation as their regrowth recovers after being burnt. For example, Guinea grass (*Megathyrsus maximus* (Jacq.) Simon & Jacobs), Signal Grass (*Brachiaria decumbens* Stapf.), Molasses Grass (*Melinis minutiflora* P. Beauv.), South African Pigeon Grass (*Setaria sphacelata* (Shumach) Stapf. & Hubb.) and *Paspalum* spp., all proliferate on moist soils and have become invasive in rainforest habitats of *P. praevenosa*. These grasses were introduced into Australia for pasture improvement but most are of very limited value to the cattle industry in coastal regions. Several of these, and other grasses, most of African origin, have become widely established and are becoming invasive in rainforest, particularly after any disturbance of soils. Some form extensive and highly flammable stands which, if burnt frequently, prevent recruitment of many native flora and gradually lead to increased flammability of vegetation over extensive areas. The combination of competition and high flammability of the grasses has become a long-term 'deadly cocktail' for rainforest ecosystems which they invade, and for the threatened animals and plants they harbour. Most known control measures for exotic grasses are temporary and only biological control could provide the effective control strategy that is now needed for a wide range of the exotic woody weeds, vines and grasses that are expanding their impacts on threatened plants and plant communities in Australia. Use of fire for controlling invasive grasses has proven to be counter-productive with re-growth of the exotic species far out-competing the growth of native species and by increasing the ground level fuel loads to pre-burn levels. Exotic grasses are the most important threat to natural recruitment of *P. praevenosa* and are now thought likely to be responsible for displacing the breeding habitats for the minute fly pollinators.

5.2.7 The Dutchman's Pipe Vine and Other Weed Vines

The introduced vine, Dutchman's Pipe vine (*Aristolochia elegans*), originally from South America, has contributed to the decline of the Richmond birdwing, and is recognised as a key threat that is not currently amenable to management in Australia. Dutchman's Pipe (Fig. 5.3) is well adapted to the same soils, water tables and climates preferred by *P. praevenosa* and it can out-compete and displace *P. praevenosa*, as well as poison the larva of Richmond birdwings (Chap. 2). The seeds of Dutchman's Pipe are carried long distances into native forests by air currents and the vine will colonise areas less accessible to other weedy vines. Adult birdwings lay their eggs on the leaves of the Dutchman's pipe vine but its leaves are poisonous to young caterpillars when they attempt to feed. In field studies adult birdwings are actually *more* likely to lay their eggs on a Dutchman's pipe vine than on *P. praevenosa* when a choice is available. Dutchman's Pipe was introduced into Australia as a decorative garden plant in the late 1800s and as is the case with all exotic plants and animals introduced at that time, the introduction did not take into consideration any 'non-target effects', including toxic compounds in the plants, poisoning of browsing livestock or the capacity for the vine to become an invasive weed in the forests of eastern Australia. At first it was assumed that the abundance of this exotic vine would be beneficial to birdwings, when females were seen ovipositing on the vine and young larvae were seen on the leaves. For example, soon after the Dutchman's Pipe was introduced into Burleigh Heads National Park, Richmond birdwings were observed laying on the introduced vine in preference to *P. praevenosa* (A. Burns pers. comm.) even when both vines were growing near one another. Around that time several well-intentioned popular articles on 'butterfly gardening' advocated planting this vine for the birdwing. It was not until sometime later that Straatman (1962) and Common and Waterhouse (1981) reported toxicity of the vine to larvae of some swallowtails when they attempted to feed on the leaves. Since the 1960s Dutchman's pipe has become a serious weed of forestry and threatened several species of swallowtails that are attracted to the vine for oviposition.

Leaves of *Aristolochia elegans* and *A. ringens* are toxic to the larvae of *O. euphorion* in northern Queensland. Some early literature includes reports of *O. priamus*

Fig. 5.3 Dutchmans Pipe Vine (*Aristolochia elegans*): (**a**) flowers; (**b**) immature seed capsule; (**c**) dehisced seed capsule; (**d**) foliage

and *O. euphorion* using *A. elegans* as a food plant (Common and Waterhouse 1981) but it is doubtful if the observations included complete development by larvae fed on this vine. Observations since made at several bushland sites in south-eastern Queensland between 1978 and 2010, by Sands and Sue Scott, confirmed the report by Straatman (1962) who showed that when eggs are deposited by *O. richmondia* on *A. elegans*, the larvae seem to emerge successfully but fail to survive beyond the 3rd instar after they commence feeding on the leaves. Meanwhile in northern Queensland, from about 1990, *A. ringens* has also become an invasive weed where it threatens swallowtail butterflies, including the Cairns birdwing, by poisoning the early instar larvae. Similarly, the toxicity by *A. elegans* to young larvae of

O. priamus has been reported from Papua New Guinea but on one occasion larvae were seen by Fred Dori to complete development by feeding on its flowers and seed capsules. Subsequently Parsons (1998) reported toxicity of *Aristolochia odoratissima* L.*,* another introduced vine, to larvae of *O. priamus*. It appears that exotic *Aristolochia* species are likely to be toxic to the larvae of Australian birdwings and their increases in density and distribution through both cultivation and spread into natural environments need to be recognised as major threatening processes for these butterflies.

A. elegans is easily distinguished from other Aristolochiaceae from subtropical regions but the heart shaped leaves bear some similarity to those of *Aristolochia chalmersii.* The large expanded flowers and parallel-sided dehiscent capsules of *A. elegans* are distinctive (Fig. 5.3).

5.2.8 Altered Fire Regimes

Pararistolochia praevenosa is one of several indigenous rainforest vines that cannot survive being burnt. On occasions the deliberate use of fire for fuel reduction burning programmes has become a most serious threat to conserving invertebrates in Australia and has also had major impacts on many rainforest plants, including *P. praevenosa* and moist forest and wetland plants. *P. praevenosa* and many other fire-sensitive plants die if rainforests are burnt and no regeneration from rootstock occurs, unlike many fire-adapted plants. One serious rising problem is the post-fire invasion by competitive weeds including African grasses that most effectively displace native plant regeneration and prevent even many fire-adapted plants from recruiting. The other problem that is becoming an increasing threat is allowing fires started to reduce fuel in dry periods in adjoining woodlands to continue burning into the forest understorey, killing many of the plants that cannot survive fires. Although agencies have been advised to avoid burning rainforests, it remains a common practice when carried out during dry periods and particularly when fires are allowed to ‘burn themselves out’. Recently agencies (State Government and Councils) have avoided burning rainforest but burning logs have often been seen to roll down steep slopes into rainforest where they may smoulder and eventually ignite the rainforest, particularly when dry during periods of drought. The high flammability of exotic *Pinus* spp., unlike the indigenous rainforest pines (*Araucaria cunninghamii* and *A. bidwilli*), and extreme heat generated by *Pinus* spp. during wild fires, can threaten all fire-sensitive plant communities when near pine plantations.

Justified by the often-voiced beliefs that ‘Australian plants (all species) evolved with fire’, ‘the need to reduce fuel’ and ‘how traditional occupants used it’, fire has been used since European settlement to burn patches of rainforest, particularly after logging or clearing, and at times during dry periods when natural fires started by lightning strikes would never have burnt rainforest or its plants. The most serious impacts to threatened terrestrial invertebrates from fires have been from the (i) scale, (ii) inappropriate seasons, (iii) frequency of deliberately-lit fires and (iv) lack of un-burnt refuges (New et al. 2010). The balance between using fire as a manipulable management tool in Australian ecosystems and fire management methods becoming a major threat to ecosystems, human property and other assets, is often a very fine one, and the potential fates of many species are simply serendipitous. Dimensions of a planned and ecologically sensitive fire regime are, in practice, often treated as secondary to simple expediency and pressures to achieve area-based control burned targets. Whilst the practice of deliberately burning rainforest in Queensland has declined over recent years, its legacy has included the impacts of invasive weeds as noted above. Regulation of control burns is ecologically complex, and is a politically charged process.

5.2.9 Inbreeding Depression

This problem was demonstrated in captive studies of several Australian Papilionidae, including *O. richmondia*, by Orr (1994). Substantial effects on egg hatching rate and larval survival and developmental rate were found with inbreeding (Fig. 5.4). Orr regarded inbreeding depression as 'potentially severe', and warned against reliance on captive breeding programmes for conservation unless care is taken to sustain a wide gene pool and avoid excessive inbreeding. Species that were previously distributed widely and now suffering from habitat reduction and fragmentation, may be those most at risk. 'Inbreeding depression' has many symptoms in reducing viability, condition, and overall 'performance'. Whilst some aspects have not been investigated experimentally in *O. richmondia*, the information provided by Orr is a salutary indication of problems that may arise, and that must be considered in a conservation strategy, with due attention to prevention of population isolation and size reduction.

There is little doubt that fragmentation of habitats and loss of corridors has led to inbreeding depression and extirpations of the Richmond birdwing under field conditions, particularly when habitat fragmentation has been due to expanding urban development, essentially providing physical barriers to natural dispersal. Loss of corridors has led to the losses of isolated populations for the butterflies even where undisturbed food plants have persisted in moderate densities, for example, in Burleigh Heads National Park, Neurum Creek National Park, and in several isolated pockets of rainforest between Brisbane and the D'Aguilar and Conondale Ranges.

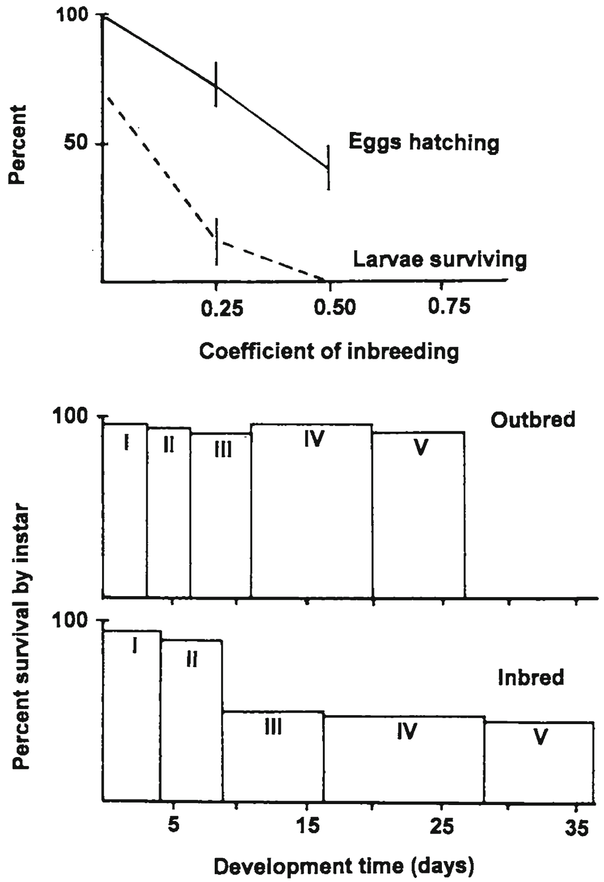


Fig. 5.4 Laboratory evidence for inbreeding impacts in *O. richmondia*: data obtained by A. G. Orr (From Orr 1994, with permission from the Queensland Museum, Brisbane)

5.3 The Draft Recovery Plan (1996)

In 1996 a Recovery Plan for the Richmond birdwing was lodged with the Commonwealth agency, the Australian Nature Conservation Agency, and was supported at that time by representatives from Queensland and New South Wales government agencies. The Recovery Plan was developed under the umbrella of CSIRO's Double Helix Science Club and CSIRO Entomology, and produced as the 'Draft Richmond Birdwing Butterfly (*Ornithoptera richmondia* [Gray]) Recovery Plan, 1996–2001, 1 May 1996'. Sands and Scott (CSIRO Entomology, Science Education Centre) were principal investigators, and the recovery team also included R. Moffatt (NSW National Parks and Wildlife Service), N. Markus

(Currumbin Sanctuary, Queensland) and P. Grimshaw (Queensland Herbarium). Although intended as a draft, the document is entitled simply ‘Recovery Plan’, implying a higher level of completion. The ‘Draft’ Recovery Plan recognised the participation of community groups in the programme, and was designed to ensure co-ordination of community organisiations, state agencies and other interest groups, and provide a plan for practical and sustainable conservation leading to the Richmond birdwing butterfly. The plan flowed in part from the December 1994 listing in Queensland of the Richmond Birdwing as a protected species under the Queensland Fauna Conservation Act. It represented the most complete summary then possible of the history of the birdwing, and the genesis of conservation concern, need, and action. It remains highly relevant.

A recovery team was formed in October 1995 with the collective affiliations noted above. The plan was lodged with the Australian Nature Conservation Agency and distributed to the Queensland Department of Environment and New South Wales National Parks and Wildlife Service on 1 May, 1996.

The Draft Recovery Plan was based on the following objectives:

- Implement strategies known to increase the declining *O. richmondia* abundance and restore the original distribution of the birdwing. Strategies include manipulating and increasing abundance of the food plants, minimising natural enemy impact and relocating individuals if genetic enhancement proves effective.
- Conduct a feasibility study for the captive rearing of *O. richmondia*, with aims to: (i) re-establish populations in areas where they have been extirpated, and (ii) enhance genetic diversity of inbred colonies of birdwings and (iii) produce live examples for public display and education.
- Form an incorporated group to encourage community participation in an ongoing conservation project on the Richmond birdwing butterfly.
- Educate the community against growing *A. elegans* (Dutchman’s Pipe), and other exotic *Aristolochia* spp. that are detrimental to birdwing survival; identify methods for control and spread of these and other threatening exotic vines.
- Understand the key natural mortality factors (including natural enemies, birdwing/food plant interactions) that affect the survival of all stages of *O. richmondia*.
- Document and protect plant communities in NSW and Queensland that are breeding habitats and flight corridors for the Richmond birdwing.
- Expand the project for cultivation and distribution of larval food plants by community groups; encourage students to fulfil the breeding requirements of colonising birdwings in urban gardens, schools, reserves and other disturbed areas.
- Improve sustainable populations of *O. richmondia* in national parks where populations of birdwings are depleted, by enrichment planting with food plants.
- Develop links between state agencies and community groups for a collaborative sustainable conservation plan for the Richmond birdwing butterfly.
- When recovery has been achieved, down-list the conservation status of *O. richmondia* from “threatened” to an appropriate lower rank, accompanied by a management plan.

The plan also specified recovery criteria (Chap. 9) and, somewhat unusually for the time, listed the actions needed for each, with nomination of lead agency and timing, as well as including a 5-year estimated budget that totalled $678 926 over the 5 years from 1996/7 to 2000/01. This draft Recovery Plan was intended to guide the recovery of the Richmond birdwing until 2000, when it would be revised and new directions added (see Sands and New 2002). Although the plan was apparently never officially ratified by State agencies, it proved an excellent informal 'working guide' to the conservation measures needed. Its development and influences, in the context of ameliorating the threats outlined here, are discussed in the next two chapters.