Chapter 4
The Natural Habitats and Resources for the Richmond Birdwing

4.1 Introduction: Ecosystems Supporting the Richmond Birdwing and Its Food Plants

In this chapter we provide background information on the environments frequented, or historically frequented, by the Richmond birdwing, to furnish the ecological context within which efforts for the species' conservation are being undertaken. The major focus addresses the supply of the most critical consumable resource, the vine *Pararistolochia praevenosa*, and the environments and vegetation associations in which it thrives. Techniques developed for propagation and plantings (Appendix 1) to contribute to the understanding of habitat enhancement and extension and their roles in defining suitable environments are also discussed. As with any specialised insect herbivore, the nature of threats to the food plant(s) and prospects for mitigation and recovery must be evaluated before recovery is attempted. In the case of the Richmond birdwing, its lowland food plant has become rare in the wild and is considered to be at risk in Queensland. The birdwing recovery programme has therefore also focussed on understanding the ecology of the food plant and protecting remaining suitable habitat patches, as well as on propagating more food plants and managing the ongoing threats to breeding birdwing populations.

O. richmondia is known to breed wherever the lowland *P. praevenosa* occurs in sufficient numbers (about 30 or more vines per patch) to support a population of the butterfly. However, without sufficient food plants or corridors to support movement of adults, inbreeding depression occurs within very few generations. Most birdwing habitats are in riparian rainforest growing on alluvial soils, or on basalt slopes not associated with water courses, but occasionally the vines grow in open, wet coastal woodlands edging rainforest, where fire has been excluded by large rocks and boulders. These habitats must also be within the 'climatic envelopes' that support survival of all birdwing stages, and the feeding and reproduction of adults. With the

D.P.A. Sands and T.R. New, *Conservation of the Richmond Birdwing Butterfly in Australia*, 77
DOI 10.1007/978-94-007-7170-3_4, © Springer Science+Business Media Dordrecht 2013

exception of the occasional, but probable dry-country habitats with the low-growing vines *Aristolochia pubera* and *A. meridionalis* (Chap. 3), the major rainforest habitats for *P. praevenosa* characteristically support a variety of shrubs, trees, sedges and vines that are adapted to growing on well-drained (but permanently moist) nutrient-rich soils with high water tables.

Climatically, the subtropical region experiences cool winters and warm to hot summers, unlike other parts of Australia except for the high and cool parts of tropical northern Queensland. Moderate to high annual rainfalls of 800–1,500 mm occur in south-eastern Queensland, whereas in parts of montane northern NSW, the average rainfall may reach 1,800 mm. Rainfall regionally is dependent on latitude, elevation, proximity of mountains to the coast (and aspect of slope); rivers, catchments and other landforms. The climate suitable for the lowland *P. praevenosa* is 'sub-tropical', indicated by the natural distribution of the vine (Fig. 3.2, p. 58) in areas with warm and moist summers and cool winters. The vine does not occur on the coast among botanically similar ecosystems north of Bundaberg, Queensland or south of Grafton, New South Wales (for example, at Coff's Harbour) indicating that its distribution is climatically limited. Other than for the outlying tropical population of *P. praevenosa* near Lake Eacham (p. 58), the vine is only known to occur at those elevations where the temperatures are much cooler than the surrounding lowlands, and somewhat similar to the subtropical parts of south-eastern Queensland. The subtropical birdwing food plants occur from sea level to about 600 m, rarely more than 60 km from the coast, in areas with an average annual rainfall above 900 mm, and mostly above 1,200–1,500 mm. In lower rainfall areas the vine only grows close to watercourses and on embankments where the moisture supports other rainforest plants with similar requirements, but in higher rainfall areas the plants will grow on slopes or cliffs where underground moisture is always present. The environmental conditions suitable for *P. praevenosa* appear to relate mostly to the climate and necessary pre-disposing conditions of soils that will support survival and germination of seeds and seedlings. In particular the nutritional requirements appear to be unusual for a rainforest plant and this is an area of research requiring much more information before the needs of the vine, its germination and seedling survival can be understood and applied to cultivation.

The amount of light reaching the wild vines influences the flowering, and the majority of flowers on any vine are produced on the most exposed terminal shoots. The same correlation applies when vines are cultivated, often flowering best in relatively open, exposed areas. Pollination may also be more effective on cultivated vines when they are exposed to moderate amounts of light, especially when vines are kept well mulched and free of weeds. Despite evidence for reduced pollination and seed set in the wild since the 1980s, vines in shaded canopies of 'old growth rainforest' continue to produce a few seed capsules. Light may influence the attraction of pollinators to flowers and the subsequent formation of healthy seed capsules. Once seeds have germinated in soil, light also plays an important part in the growth rate of seedlings or young vines of *P. praevenosa*. If seedlings develop

under shaded canopies, the growth can be very slow regardless of existing suitable nutrients, moisture and drainage. In common with many rainforest plants, germination of seeds and rapid growth occurs most often in places where a limb or tree has fallen, providing a temporary 'light gap' to illuminate the ground surface. Similarly, seed germination can be frequent at the edge of rainforest canopies, allowing light into areas where brush turkeys have been scratching the soil containing seeds. Brush turkeys are attracted to the pulp from fallen seed capsules and also to the soils where seedlings are actively germinating or growing in natural bushland or gardens.

4.2 The Bioregions and Limited Distribution of Vines

Subtropical landscapes covering the coastal plains, waterways, hills and mountains of north-eastern NSW and south-eastern Queensland support some of the richest biodiversity in Australia, with the range of endemic invertebrates in this region as significant, or sometimes more so, as the species of the wet tropics of northern Australia. The Richmond birdwing and its lowland food plant originally occurred between the eastern slopes of the Main Dividing Range and the eastern coast in northeastern NSW and southeastern Queensland. The two state regions occupied by the butterfly were affiliated with several major river systems with their headwaters descending eastwards from the Main Divide, draining more or less towards the coast. From north to south the major river systems (Fig. 4.1) have broad, nutrient-rich and moist alluvial soils on flood plains, often surrounded by volcanic ranges. In Queensland these are the Mary, Stanley, and Brisbane Rivers and in NSW, the Tweed, Richmond and Clarence Rivers, based on the major catchments. These bioregions include the known distributional boundaries of the Richmond birdwing butterfly and its food plants, as well as many other endemic subtropical insects. Past climates, soils and natural (that is, not human-imposed) fire regimes are the major forces that influenced the evolution and diversity of the Australian plants and animals. The southeastern part of Queensland has been considered a distinct bioregion with Regional Ecosystems (Bean et al. 1998; Sattler and Williams 1999), based on plant species and plant communities. Included in this subtropical bioregion, is a semi-rectangular area (about 330 km long and 130 km wide) bounded to the east by the Pacific Coast, to the west by the main Divide, and extending south from the Mary River to the Queensland-NSW Border. In NSW, a similar bioregion extends west from the Tweed River, to the Main Range and Richmond Range, south to the Clarence River. Rainfall in Queensland is seasonally moderate near Brisbane (approximately 1,000 mm) but higher and annually more uniform (ca 1,500 mm) to the north and south of Brisbane. In NSW high rainfall occurs from the State border to the Richmond River, but it declines south in the Clarence River Catchment and on the floodplains approaching Grafton.

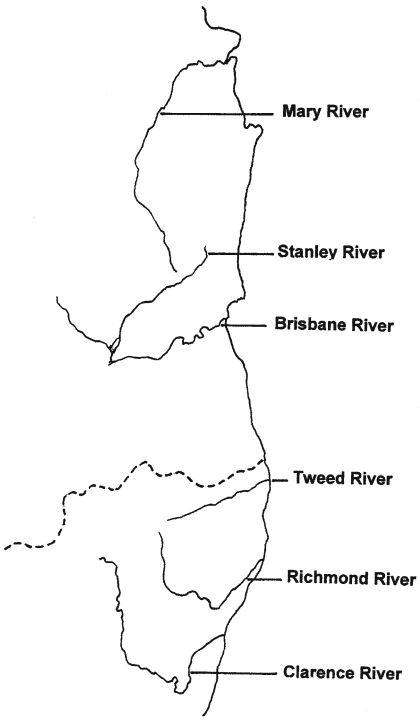

Fig. 4.1 Major river systems in region, as possible guide to restoration sites. Note that Stanley River is a tributary of the Brisbane River (State border indicated by dashed line)

In layman's terms, the major habitats supporting breeding populations of Richmond birdwings are: (i) riparian rainforest, growing on steep embankments or alluvial slopes; (ii) floodplains, with high water tables where rainforest often merges with riparian slopes; and (iii) basaltic caps and rock-strewn (volcanic) steep slopes. The Main Dividing Range supports many unique species of invertebrates and plants adapted to the cooler and wetter climate, especially near the Queensland-New South Wales (NSW) border. Biodiversity is especially rich in the area where the Macpherson Range intercepts the Main Range, near Mount Barney, and to the east where a volcanic rim encircles Mount Warning, the core of an extinct volcano. In NSW, Mount Warning was the volcanic core and origin of basaltic flows that formed rich soils supporting the habitats for the Richmond birdwing butterfly. In south-eastern Queensland, including the Glasshouse Mountains and north to Mount Eerwah, remnants of earlier volcanic plugs and basaltic flows (Willmott 2007) have contributed to the formation of two sub-coastal ranges, the Blackall and Conondale Ranges (Fig. 2.10, p. 47). Their rich soils and high rainfalls support suites of distinctive plants and subtropical invertebrates. Extending to the north and from west of Brisbane, the dryer D'Aguilar Range supports habitat remnants (including those of the Richmond birdwing) in the very few protected areas, near Mount Glorious, Mount Mee and Mount Coot-tha (formerly referred to as part of the 'Taylor Range'). However,

reflecting their proximity to Brisbane these areas have suffered most from logging, farming, burning, weeds and urban development. Several species of insects are known only from the D'Aguilar Range (for example, the wood moth, *Endoxyla pulchra* (Rothschild) Cossidae), and may now be extinct, and the habitats for many other Lepidoptera are few, fragmented or confined to the northern end of their original range.

The underlying rocks and soils supporting naturally-growing *P. praevenosa* have several characteristics in common but the vines grow only on well-drained soils that do not dry out. However, they never grow on flat and swampy soils and the slopes preferred have high underground water flows. Sub-tropical rainforest plant communities are the basic arenas for the Richmond birdwings and habitats for its lowland food plant vine.

These ecosystems were designated by the Australian Commonwealth Government as Critically Endangered Ecosystems (2011) and only very small areas remain intact in Queensland and New South Wales. The formal title for these ecosystems, declared on 25 November 2011, is 'Lowland Rainforest of Subtropical Australia', with the comment that the epithet 'Subtropical' is used to describe the climatic zone in which the community generally occurs, rather than a specific kind of rainforest. The advice to the Minister preceding listing noted its primary occurrence from Maryborough to the Clarence River, with isolated more southerly outliers, on basalt and alluvial soils. Although not mentioning *O. richmondia* specifically, that advice noted the substantial number of species found there (63 plants, 42 animals) that were listed under national or state legislations by early 2011. Many of the animals and plants in these ecosystems continue to be threatened by various commercial activities, fragmentation, weed invasions and human 'use' of the natural resources, such as mining of volcanic rocks for road bases, and unregulated horse and bike riding. The advice also acknowledges that 'Fragmentation can affect invertebrate species dramatically as they are short-lived and sensitive to fine-scale environmental variation' (p. 20). The community was declared eligible for listing on four of the Act's criteria: (Criterion 1) 'decline in general distribution is severe'; (Criterion 2) 'geographic distribution is very restricted and nature of the distribution makes it likely that the action of a threatening process could cause it to be lost in the immediate future'; (Criterion 3) 'the decline of functionally important species is severe and restoration is unlikely to be possible in the near future'; (Criterion 4) 'the ecological community has undergone a severe reduction in community integrity such that regeneration is unlikely within the near future'. Lack of quantitative information precluded eligibility under the other two criteria referring to rate of detrimental changes and quantitative estimates of probability of extinction. It is hoped that the EPBC designation will ensure protection of remaining natural fragments of the rainforests in subtropical regions in a way similar to the protection requirements of tropical rainforests of northern Queensland. However, the Minister decided not to have a recovery plan for this ecological community as 'the planning, implementation and coordination of recovery actions does not involve complexity beyond that which can be managed through existing management plans and processes'.

The soil types most favoured by *P. praevenosa* are usually rich in nutrients and decomposing plant materials. Preferred are basalt 'basic' soils with a pH between 6.6 and 6.8, on which vines may form large colonies of 'old growth birdwing vines', sometimes with 50 or more old stems arising from rhizomes in clumps (Fig. 4.2). In the old vines**,** upright stems are often widely-spaced when arising from rhizomes or branch laterally near the bases of the stems. In the more acidic soils (pH 6.2–6.6), the vine densities become fewer as the pH decreases. *P. praevenosa* is naturally most abundant on moist/wet volcanic soils, particularly the basaltic soils on slopes (including those above sea fronts), caps and flows. Volcanic soils derived from basalt or rhyolite, and low in silica, are those most commonly associated with *P. praevenosa* but occasionally the food plant will grow on soils derived from metamorphic rocks, or rarely, soils based on shale, sandstone or sandy loam. The main features of the associated rainforest communities relate to the permanent underground moisture and flows, and streams with some flow and little stagnation. Vines often grow on moderately or steeply-sloped embankments, or in riparian vegetation near streams. A further 'preference' for the vines is rhyolite soils edging stream embankments, followed by nutrient-rich riparian alluvium supporting plant species with similar environmental requirements.

Fig. 4.2 Old vines of *P. praevenosa* in the field: (**a**) vines growing into roots of a fig (*Ficus virens* Aiton) supporting a mature vine of *P. praevenosa* (P. Grimshaw); (**b**) vines ascending into forest canopy (P. Grimshaw)

The habitats thereby range from flat, flood-prone plains to steep volcanic slopes near the sea and mountainous country. Rarely are old nutrient-rich sand dunes, or shale-based soils colonised. Least commonly the vine occurs in rainforests growing on old, nutrient-rich and coastal sand dunes, or sand over volcanic soils. These sand-based habitats are rare and a few that were formerly present near the coast in Queensland have now been destroyed by sand mining, logging, weed invasions and urban development. One such habitat remains relatively intact at Cudgen Nature Reserve, NSW but a similar old sand dune system at Point Arkwright, Queensland, with many rare plants

Table 4.1 Indigenous nectar-producing flowers most attractive to adult *Ornithoptera richmondia*

Common name	Scientific name
Blue Quandong	*Elaeocarpus grandis* F. Muell. Elaeocarpaceae
Black Bean	*Castanospermum australe* Hook. Fabaceae
White cedar	*Melia azedarach* L. var. *australasica* (Francis). Meliaceae
Red cedar	*Toona australis* (F. Muell.) Haines. Meliaceae
Eucalypts	*Eucalyptus* L'Her. spp. Myrtaceae
Bottlebrush spp.	*Melaleuca* L. spp. Myrtaceae
Brush Cherry	*Syzygium australe* (Link) B. Hyland. Myrtaceae
Weeping Lillipilly	*Waterhousia floribunda* (F. Muell.) B. Hyland. Myrtaceae
Native Frangipani	*Hymenosporum flavum* (Hook.) F. Muell. Pittosporaceae
Red Silky Oak	*Alloxylon pinnatum* (Maiden & Betche) P.H. Weston &Crisp (>600 m). Proteaceae
White Yiel-Yiel	*Grevillea hilliania* F. Muell. Proteaceae
Grevillea spp. and hybrids	*Grevillea* J. Knight spp. Proteaceae
Wheel of Fire	*Stenocarpus sinuatus* (Loudon) Endl. Proteaceae
Butterfly Bush	*Pavetta australiensis* Bremek. Rubiaceae
Pink Euodia	*Melicope elleryana* (F. Muell.) T.G. Hartley. Rutaceae
Native Tamarind	*Diploglottis australis* (G.Don.) Radlk. Sapindaceae
Grass Trees	*Xanthorrhoea* Sol. ex Sm. spp. Xanthorrhoeaceae

affected, was partly destroyed for housing development (Sands and Scott 2001). *P. praevenosa* does not grow on alkaline soils such as limestone-based soils and prefers almost neutral, slightly acidic soils. *P. praevenosa* is sometimes protected from being burnt by large volcanic rocks surrounding the base of the vines.

4.2.1 Flowers as Nectar Sources for Adult Birdwings

The Richmond birdwing will search for flowers of many rainforest trees close to the breeding sites, or travel considerable distances into more open or dryer areas to obtain nectar from woodland species or even exotic plants, for example lantana. However, rainforest flowering trees are the favoured sources of nectar for adults in lowland birdwing habitats (Table 4.1).

Flowering by *Eucalyptus grandis* W. Hill occurs intermittently but this species is an important source of nectar for adults, while other eucalypt species growing outside of the rainforest, are visited. The Black Bean, *Castanospermum australe* Hook., is a prolific flowerer but it is very seasonal (November), producing its red and yellow flowers abundantly and often visited by birdwings and birds when both are seeking nectar at the same time. Another important source of nectar is the native frangipani, *Hymenosporum flavum* (Fig. 4.3), a hardy tree producing cream flowers, darkening to yellow and produced in great profusion in spring. It is sometimes the only plant providing nectar for adult birdwings at that time of the year and during periods of prolonged drought. The flowers of *Melaleuca quinquenervia* (Cav.) S. T. Blake, are also a favoured source of nectar, across a wider seasonal range.

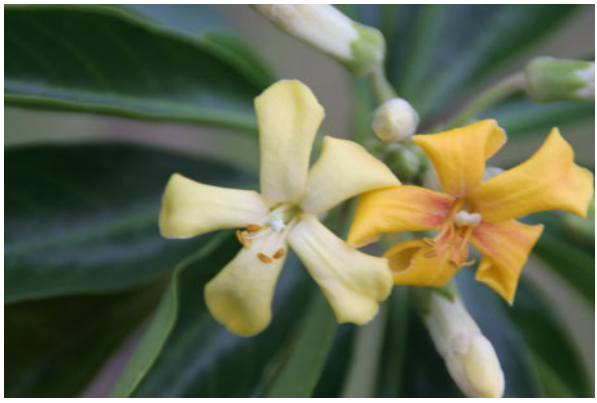

Fig. 4.3 Flowers of *Hymenosporum flavum*: an important nectar source of birdwings in spring

The plants most often associated with *P. praevenosa* were discussed by Sands and Scott (1996) and the list was revised in 2010 (see Table 4.2) Some palms are commonly associated with *P. praevenosa* and they can often tolerate flooding, desiccation and/or fire. For example, *Archontophoenix cunninghamiana* is commonly associated with the vine. The palm is very fire sensitive and usually grows close to running water where the palm can tolerate regular flooding, unlike *P. praevenosa.* The Cabbage palm, *Livistona australis,* is sometimes associated with *P. praevenosa* (for example, in Burleigh Heads National Park, Queensland), particularly when in more open types of rainforest, or areas exposed to sea mists. This palm can regrow after fire and sometimes occurs with *P. praevenosa* on flat alluvial soils or moist volcanic soils on moderate slopes. *L. australis* is one of the few rainforest palms in Australia that can recover after being burnt, and is sometimes seen when rainforests are burnt during forestry operations aiming to induce seedling germination of eucalypts. Both *A. cunninghamiana* and *Livistona australis* occasionally grow in the same areas as *P. praevenosa*. The walking stick palm, *Linospadix monostachya*, a small understorey palm, provides a good indication for types of soils that are most suitable for *P. praevenosa*, where it may occur uncommonly at the higher and wetter sites and on soils rich in nutrients.

4.2.1.1 Plants Supporting Climbing Vines

The most abundant rainforest trees and vines associated with *P. praevenosa,* and those that provide support for the climbing vines, are listed in Table 4.2. Support to *P. praevenosa* by other vines is often mutual, adding strength as they twine into the canopy. The common vines associated with *P. praevenosa*, are referred to as 'companion vines', and include a prickly-stemmed palm, the 'lawyer vine' *Calamus muelleri*, and 'supplejack', *Flagellaria indica*, a slender-stemmed, bamboo-like vine. *F. indica* is one of the most reliable 'indicator' plants that is used when searching for the environmental conditions suited to *P. praevenosa*. Hoop Pine (*Araucaria cunninghamii* Aiton ex A. Cunn. Var. *cunninghamii*) and Flooded Gum (*Eucalyptus grandis*), although often found in rainforests with *P. praevenosa*, do not alone

Table 4.2 Plants often associated with the habitats of *P. praevenosa*

Trees and shrubs
Cordyline R. Br. spp. Agavaceae
Araucaria cunninghamii Aiton ex G.Don. Araucariaceae
Aphananthe philippinensis Planch. Cannabacaeae
Elaeocarpus grandis F. Muell. Elaeocarpaceae
Sloanea woolsii F. Muell. Elaeocarpaceae
Eupomatia laurina R. Br. Eupomataceae
Castanospermum australe A. Cunn ex Muo. Fabaceae
Cryptocarya hypospodia F. Muell. Lauraceae
C. obovata R. Br. Lauraceae
C. triplinervis R. Br. Lauraceae
Neolitsea dealbata Br. (Merr.) Lauraceae
Endiandra pubens Meissner. Lauraceae
Argyrodendron trifoliolatum F. Muell. Malvaceae
Wilkiea macrophylla (R. Cunn) A.DC. Monimiaceae
Ficus coronata Spin. Moraceae
F. fraseri Miq. Moraceae
F. watkinsiana Bailey. Moraceae
Ficus macrophylla Pers. Moraceae
Streblus brunonianus (Endl.) F. Muell. Moraceae
Eucalyptus grandis Hill ex Maiden. Myrtaceae
Syzygium francisii L.A.S. Johnson. Myrtaceae
Waterhousia floribunda (F. Muell.) B. Hyland. Myrtaceae
Grevillea robusta A. Cunn. ex R. Br. Proteaceae
Arytera lautereriana F.M. Bailey (Radlk). Sapindaceae
Diploglottis australis Cunn. (Radlk). Sapindaceae
Dendrocnide excelsa (Wedd.) Chew. Urticaceae
D. photinophylla (Kunth) Chew. Urticaceae
Gmelina leichardtii (F. Muell.) Benth. Verbenaceae
Vines and palms
Deeringia arborescens (R.Br.) Druce. Amaranthaceae
Melodorum leichhardtii (F. Muell.) Benth. Annonaceae
Archontophoenix cunninghamiana (H.A. Wendl) H.A. Wendl & Druce. Arecaceae
Calamus muelleri H.A. Wendl. Arecaceae
Livistona australis (R. Br.) C. Martius. Arecaceae
Flagellaria indica L. Flagellariaceae
Carronia multisepalea F. Muell. Menispermaceae
Pleogyne australis Benth. Menispermaceae
Sarcopetalum harveyanum F. Muell. Menispermaceae
Hypserpa decumbens (Benth,) Diels. Menispermaceae
Cissus antarctica Vent. Vitaceae
C. hypoglauca A. Gray. Vitaceae

provide the support necessary for vines ascending into the canopy. Many species of trees and shrubs serve as natural supports for *P. praevenosa* in rainforest and only a few are referred to here. One of these, the 'Gympie stinger' *Dendrocnide excelsa*

(Wedd.) Chew is an important support tree and curiously, it has been the fear by loggers of making contact with the foliage and stems of this tree that has spared both the stinging tree and several of the 'old growth' birdwing vines. Rainforest-adapted eucalypts including *E. grandis*, do not appear to act as supports for vines, probably due to their smooth, broad trunks preventing adhesion for climbing by the vines. Several different species of *Ficus* are important as supporting frameworks for *P. praevenosa*. They include *F. virens* Aiton, a deciduous tree that in spring as temperatures rise, promotes rapid growth of *P. praevenosa* following leaf fall, and when sunlight reaches the vine apices. The fall of pupae attached to dropping leaves from this tree is sometimes avoided by the larva spinning silk around the leaf petiole and then silk is spun to circle the stem, preventing both leaf and pupa being shed. Other tall species of figs, *Ficus rubiginosa* Desf. ex Vent. form *rubiginosa, F. superba* var. *henniana* (Miq.) Corner, *F. macrophylla* Desf. ex Pers. form *macrophylla* and a strangler fig, *F. watkinsiana* F.M. Bailey, will support large and ageing vines, often with the stems arising from between the buttress roots of figs where they are largely protected from disturbance. The large buttress roots of figs provide pockets of shelter and permanent moisture that assist survival in dry periods and the buttress roots may also protect the moist leaf litter, enabling seedlings to survive. The combination of fig buttress roots and roots binding large rocks, provides one of the most important habitats for protection and survival of 'old growth' vines.

4.3 Subtropical Plant Communities Associated with *P. praevenosa* in New South Wales and Queensland

The major structural types of Australian rainforests were broadly proposed by Webb (1978) and described in more detail by Webb et al. (1984). Using this scheme, subtropical habitats for the Richmond birdwing can be referred to as (i) Complex notophyll vine forest – seasonal wet/moist, and (ii) Araucarian notophyll vine forest. In Queensland the plant communities have also been classified according to bioregions, soil types and plant associations. This three-point numerical system has been used to define 'regional ecosystems' (REs); the first number indicating bioregion (12 = SE Qld); the second number, soil types and the third number, plant communities. The constitutions of the various relevant communities are listed in Appendix 2, in which the considerable subtle variety in this botanically rich region is very evident.

4.4 Possible Impacts from Climate Change

Concerns have been expressed by many biologists over the possible ways in which changing coastal climates, driven by the recent and rapid increases in ocean temperatures (currently estimated at around 0.8 °C), are affecting the distribution and survival of plants and plant-dependent animals in Australia. The impacts are likely to be felt most strongly amongst subtropical endemic species having narrow ranges of

adaptation to temperatures and moisture, especially when the subtropical ecosystem remnants are already small and fragmented. Prolonged periods of drought between 2002 and 2008 had a particularly serious impact on naturally occurring vines and several growing naturally in Burleigh Heads and Neurum National Parks died completely. For *P. praevenosa,* adaptation to subtropical climates is likely to have determined the distribution of the vine in eastern Australia, with no evidence of this plant occurring between the small area occupied on the Northern Tablelands and the current distribution south of Maryborough. This suggests a former but wider distribution into parts of the tropics. Without further loss of habitats and taking into account the slow reproduction of *P. praevenosa,* the vine may be a candidate for extirpations occurring in the northern parts of its range due to increasing temperatures and to prolonged droughts.

For the birdwing butterfly and its early stages, sensitivity to extreme temperatures outside of previous 'normal' subtropical ranges can be expected to lead to extirpations, even if the food plant can survive and reproduce. The current distribution of *O. richmondia* indicates that the species is adapted to cool winters needed for diapausing pupae but desiccation occurs when temperatures are abnormally high. Emergence of adults usually occurs over a relatively short season (of about six weeks) when day length, temperatures and moisture increase in spring. The winter diapause indicates a life history different from the tropical species, including *O. euphorion*, in which protracted development is temperature dependent. Outside of the natural range of *O. richmondia*, in coastal regions north of Maryborough, climates are unlikely to be suitable; for example erratic emergence of adults would occur following break in diapause throughout the cooler months. Similar disruption in development occurred during the prolonged drought of 2001–2012 in south-eastern Queensland, when occasional winter emergences occurred at times when the individuals were unable to find a mate, and eggs deposited by unmated females were infertile. If climate change disrupts break in pupal diapause over a long period, individuals will not only emerge when densities are too low for reliably finding a mate but mating by siblings is more likely to lead to inbreeding depression. Overall, the disruption to any developmental cycle that leads to protracted emergences of adults is likely to lead to inbreeding effects. Clearly, the details of any such projected impacts must be speculative, and assessed against the mobility of the birdwing and its possible future distribution, as well as that of its critical resources.

The most likely relevant effects from climate change will be on the distribution, survival and reproduction of *P. praevenosa* in subtropical Australia, particularly through its pollinator/s. The vine occupies a definite subtropical 'climatic window'. It is not known from coastal localities north of about Maryborough and the only other northern locality known, the Atherton Tablelands, also has a subtropical climate. Although there are many remaining small pockets of lowland rainforest (such as those near Rockhampton, Mackay and Proserpine) and some on the ranges, there are no records of *P. praevenosa* from these localities, suggesting strongly that the climate, although within apparently suitable ecosystems, may have been too warm for survival and reproduction of the vine. This presumption also applies to several other subtropical plants that are associated with the climatic regions where *P. praevenosa* occurs naturally. With an average increase of only 0.5 °C on the coast, the vines would be unlikely to survive or reproduce north

from about Brisbane and on the lower mountains they could also retreat from places such as Eumundi and the Conondale Ranges. Changes in rainfall cycles are also predicted to affect the growth of the vines following climate change, particularly the erratic production of soft leaves that follows long drought periods; the vines are always dependent on abundant moisture.

Other animals are associated with birdwing habitats through regular association or also feeding on vines. Brush turkeys were always present at the natural sites where they provided a major, or the only natural activity (by scratching) that leads to burial and germination of seeds of both *Pararistolochia* spp. On one occasion at Eerwah Vale, Queensland, seedlings were observed germinating on the embankment of a creek, thought to be due to the carriage of the seeds or the capsules downstream by floodwaters. However, this was not a common occurrence and seed recruitment was nearly always only observed very close to the parent plants that were producing seeds. Insects associated with the habitats for the food plants included the minute pollinators of the vines and occasionally the larvae of a moth**,** *Tiracola plagiata* (Walker) (Erebidae), a widespread polyphagous species which is sometimes a serious pest of crops, observed feeding on the young leaves of *P. praevenosa*, particularly during winter months when no larvae of *O. richmondia* are present. In addition, the 'Big greasy' (*Cressida cressida*), will oviposit on small vines (usually < 1 m) of *P. praevenosa* and use the low-growing and younger vines as a food plant for its larvae, especially if they are growing in areas exposed to sunlight, and when growing near the usual food plant, *Aristolochia meridionalis*.

Predatory insects, especially ants, spiders and mites (*Charletonia* sp.) are often seen on the leaves of *P. praevenosa* and at times, may become important predators of the eggs and larvae of the Richmond birdwing (Chap. 2).

4.5 Locating Habitats with the Birdwing Food Plants and Protecting Their Tenure: What Is Now Needed?

Surveys and mapping. Since interest in conserving the habitats of the Richmond birdwing began in the early 1990s, surveys and some distribution mapping of the principal food plant, *P. praevenosa,* have been carried out in the better-known parts of southeastern Queensland, but far fewer records have been accumulated from the remote areas of Queensland and New South Wales. Many of the records have come from native plant enthusiasts, members of Landcare and other community groups. Land with various tenures, including State and council owned parks, forestry areas and private properties has been surveyed for the vines. Participants all helped by gathering information on the whereabouts of the vine and the tenure of the habitats and initially the records were lodged with the Queensland Herbarium. However, it soon became clear that misidentification of vines by non-botanists sometimes hindered assembly of accurate information on *P. praevenosa.* Only the collection of voucher specimens or detailed and close-up photographs could confirm the identities and legal requirement for a permit to collect this protected vine was a deterrent to collection of voucher specimens. By 2000, as good quality and reasonably-priced

digital cameras became popular, high resolution close-up pictures enabled increased levels of accurate identification using images of leaves, stems, flowers and seed capsules of the vine. By the time the Richmond Birdwing Recovery Network Inc. (RBRN) was formed in 2005, the identities of vines could be confirmed relatively easily without the widespread need for voucher specimens. Several RBRN members, including Philip Moran and Andrew Wilson, developed simple methods to distinguish common 'look-alike' rainforest vines (p. 69) from *P. praevenosa* and these were included with suitable images (Fig. 4.4) in the series of Workshop Supplements. Accurate identification of the poisonous Dutchman's pipe vine (*A. elegans*) also formed an important part of the workshop proceedings but infestations of this weedy vine were not included in the surveys.

Fig. 4.4 Look-alike vines: Workshop Bulletin (**a**) cover; (**b**) page details to characterise each local species

4.6 Needs for Remnant Habitat Conservation

Australian National Parks have been considered to be the most appropriate tenure to protect natural habitats for fauna and flora in Australia, particularly for those species that are designated as rare or threatened, and those that need specific and/or undisturbed habitats. In the past, Australian National Parks, once designated as protected areas, have been managed as places where the threats to their ecosystems are least, or where threats can be addressed. However, the security of many of these sites began to change in the 1990s with weed invasions, damage from animals such as deer, foxes and hares, and domestic dogs and cats that have become feral. Recent management of many national parks has become seriously deficient with loss of personnel and erosion of support resources and finance, and deliberately-lit fires have sometimes placed pressures on the integrity of these 'indefinitely-protected' areas and the survival of many species of plants and small animals. Since 2000 it has become a matter of concern that the tenure of national parks in Australia is not

always secure; most are in practice State-owned parks, where management by the state agencies may vary with each government elected, and for which long-term conservation planning and security is not assured.

Only rarely does national parks management in Queensland extend to controlling invasive weeds, exotic animals such as foxes, or excluding fire from fire sensitive ecosystems. Management is needed to protect habitats against these threats when recovering the Richmond birdwing. Very few national parks contain *P. praevenosa* naturally, and fewer than 20 % of the subtropical rainforest communities protected in national parks are known to support the vine. Outside of national parks almost all other habitats for the vine are potentially at risk from clearing of natural vegetation, weed invasion, commercial development and mining. In Queensland the most important areas for long-term protection of habitats and food plants for *O. richmondia* are on privately-owned land and national parks in the Conondale and Blackall Ranges. In New South Wales, the Mount Warning and Broken Head National Parks are the best known habitats already protected as well as several other important protected areas (such as Mount Nardi) of lowland subtropical rainforest that are inhabited by the Richmond birdwing.

For some sites now rehabilitated and planted with *P. praevenosa*, the lack of secure tenure has continued to be of concern, with protection of wild populations of the Richmond birdwing seen as needing securely protected national parks with commitment and obligation to protect the key habitats for the future. However, In Queensland only 4.8 % of the State is currently declared as national parks. The protection of these parks may, since 2012, no longer be sufficiently secure to prevent various new sources of disturbance (now reported to be 'opened up' for recreational activities), following recent suggested changes to usage threatening many species that are dependent on these parks for their remaining habitats. On privately-owned land in Queensland provision has been made for securing tenure of privately-owned land as 'nature refuges', by an individual agreement reached between land owner and government agency, but since 2012, new threats to the stability of this tenure mean that managers of national parks can no longer guarantee habitat security. Despite these concerns, nature refuges established on privately-owned land are believed to be the best way of protecting the approximately 75 % of Richmond birdwing habitats, for areas where *P. praevenosa* is growing naturally. A further option is for landowners to choose to protect patches of birdwing habitat through local council covenants but the security of these is now also in doubt in some municipalities, particularly when ownership is transferred, and new owners have different priorities.

4.7 Restoring Bushland Habitats on Private and Public Land

With fewer than 15 % of known localities where *P. praevenosa* occurs sited in national parks in south-eastern Queensland, planning is needed to: (i) ensure protected areas such as national parks are indefinitely secured against human disturbance, (ii) increase the number of wild vine sites protected on privately-owned land, and (iii) identify suitable government-owned land for rehabilitation as core areas, to

be planted with *P. praevenosa*. All categories of land tenure may contribute to such measures to ensure the habitats can be protected against disturbance, and managed to protect the food plants and butterflies. While similar programmes have been in place in Victoria for other butterflies for many years (for example, to protect the Eltham Copper butterfly in Victoria: New 2011c), 'species habitat focus' for conserving and rehabilitating threatened species of invertebrates has not been developed in Queensland. However, one locality in Queensland, the Mary Cairncross Scenic Reserve at Maleny, has expanded an area edging a natural birdwing habitat, by planting a selected area with *P. praevenosa* on a complex of specially-constructed trellises (Fig. 4.5c). By 2009 these plantings had produced exciting results, first by encouraging public interest in planting vines and viewing the butterflies but also evidence that birdwing numbers are stabilizing and perhaps even increasing in the area. Mary Cairncross Scenic Reserve can now be recognized as one of the few secure and government (Sunshine Coast City Council) owned 'core habitats' that are contributing to recovery of the Richmond birdwing. With substantial areas of intact rainforest this Reserve is a wildlife refuge that protects many other subtropical and threatened animals and plants. Emulation of the effort to produce other 'core areas' as major habitat foci for *O. richmondia* is highly desirable.

Fig. 4.5 Trellises constructed in the field for establishment of *P. praevenosa*: (**a**, **b**) recent plantings in a school ground near Brisbane; (**c**) maturing vines in a public area and education deck, Mary Cairncross Scenic Reserve; (**d**) small trellis at site near Brisbane

The twin foci for habitat recovery actions reflect (i) individual sites and (ii) connectivity. The key recovery actions for the Richmond birdwing will both depend on providing sufficient food plants in suitable places to sustain breeding populations of the butterfly throughout its former natural range, whilst also mitigating threats. Riparian vegetation 'corridors' that will allow and promote movement between breeding populations are also essential to facilitate outcrossing between genetically different populations, as a means to prevent inbreeding depression. In addition, 'core recovery areas' are needed where habitat and food plants are sufficient to sustain local breeding as well as enriching 'core breeding sites', areas where breeding has continued but the densities of food plants have been insufficient to sustain local populations indefinitely. Additional flowering trees and shrubs are also needed in some areas despite the often suitable nature of exotic flowering plants that often provide adequate nectar.

Major efforts were made from 2005 to 2009 to plant hundreds of *P. praevenosa* vines, and this proved to be the most popular way of monitoring the health and progress of the vines by members of the community. Sites planted on privately-owned land were recorded on a database as 'links' (with owners' permission) and sites planted on government-owned land were referred to as 'stations'. With more than 2,000 vines planted during that period, monitoring the growth, stagnation or death of vines provided information on a wide range of factors, including the best soils, shading and supports for the vines, to guide future efforts. Most of the causes of vine death were identified. For example, when the disastrous floods in January 2011 swept through south-eastern Queensland, many of the vines were planted too close to the creeks in flood on embankments and were swept away, indicating that vines need to be secured above the 'high-water' levels of creeks when they are prone to flooding. To continue recovery efforts for the Richmond birdwing the methods used for planting *P. praevenosa* in links and stations need to be extended and, if possible, supported by local councils under their plant rehabilitation programmes. In addition, more formal plans are needed to link the fragmented sites, both with planted and natural vines, as parts of corridors to enable breeding colonies to move appropriately and avoid inbreeding depression. This somewhat idealistic approach is 'what is needed' as part of the practical recovery process for the threatened butterfly.

The plans for core recovery sites and habitat stepping stones have driven many of the conservation actions since establishment of the first southern core recovery site at the Canungra military base in early late 1990s. Experience implies that key or core recovery sites should be planted with at least 30 *P. praevenosa* per 'patch' and these maintained (through regular watering and mulching) at each site and spacing between adjacent sites should ideally not be more than 5 km, in 'planted corridors' to ensure the average range of dispersal of butterflies will occur in the areas marked for recovery. Since the interest in conserving the Richmond birdwing began in the 1990s, an overall aim of the project has been to 'Bring the Richmond birdwing back to Brisbane', and to locate and protect any remaining breeding populations in the municipality. Suitable habitats may have been present at Breakfast Creek, or at South Bank, on the Brisbane River but no remnant vegetation survived the floods of 1972. It was not known where the original habitats for the Richmond birdwing were located but it is probable that until the 1940s, suitable rainforest patches in the suburbs supported the

butterfly at Ithaca Creek near Bardon, at Brookfield and along Moggill Creek to the west (as evident from the early Illidge [1924a] sightings) near Bulimba Creek to the east and at Mount Cotton to the south of Brisbane. These localities had plant communities suitable for *P. praevenosa*, based on existing plants usually associated with the vine, and historical sightings of adults. Since about 1992, the increasing numbers of enthusiastic conservationists involved in the Richmond birdwing project searched the Brisbane suburbs for remnant patches of rainforest with the food plants, and to identify areas of plant communities where *Paristolochia praevenosa* could be successfully planted. With much clearing and urbanisation near Brisbane that followed observations of birdwings by Illidge (1927), little rainforest vegetation has remained, and the search concentrated on surviving 'habitat indicator' plants (such as *Flagellaria indica*) on the major creeks. In the 1970s and as a result of the 1972 floods in Brisbane, waterways and streams became widened or deepened for flood mitigation; and many streams were confined in pipes and buried before over-laying with urban developments and open parklands. Almost all remaining potential habitats became infested with exotic weeds and this led to clearing and mowing of most riparian vegetation near the City. Planning habitat restoration in Brisbane by planting food plant vines began in about 1978 and plans for identifying potential sites commenced in 1989, after difficulties with producing healthy seedlings had been overcome.

Planting more food plant vines from 2010 is continuing as a key objective for the Wildlife Preservation Society of Queensland, now hosting the community Group, the Richmond Birdwing Conservation Network (Chap. 7). The first 'core' site proposed for Brisbane was the University Mine site at Indooroopilly, close to the Brisbane River and only about 5 km from Brisbane City. Although all natural habitats around Brisbane had been destroyed by about 2000, in 2010 this area at Indooroopilly was identified as capable of providing the necessary habitat for the butterfly and its food plant and it has been planted with more than 80 vines of *P. praevenosa* in a flood-free area, numbers thought capable of supporting a birdwing colony. Several adults have been sighted in Brisbane since the sighting by Jonsson (2008) and birdwing larvae have since been seen in 2010 by Richard Bull, near the core site at Indooroopilly. By taking advantage of the suitable soils, slopes and central location the Indooroopilly site was considered suitable for providing one valuable habitat stepping stone in an old corridor, near the Brisbane River.

In 2005, creek catchments in Brisbane, proposed by members of the Richmond Birdwing Recovery Network for rehabilitation and planting of *P. praevenosa,* included Western Suburbs: Pullen Pullen Creek, Moggill Creek, Cubberla Creek, Enoggera Creek below Enoggera Dam, Ithaca Creek at Bardon; Eastern Suburbs: Downfall Creek, Bulimba Creek; Southern and eastern Suburbs: Buhot Creek, Tingalpa Creek, Oxley Creek, Eprapah Creek in Redlands Shire and Logan River. The western localities were mostly riparian patches edging creeks, and except for Cubberla and Witton Creek, water courses drained areas of riparian rainforest that alternated with dry patches of non-rainforest trees including casuarinas, eucalypts and *Melaleuca* spp., along the creeks. One or two small creeks close to the Brisbane River, rehabilitated and planted with vines over 2005–2008, were badly damaged by floodwaters in January 2011.

The broadscale planting programme began in Brisbane in the Western suburbs by selecting riparian public areas that could be recovered by weed removal, and suitable peri-urban private gardens where remnants and planted native vegetation provided the necessary shading and support for the food plant vines (Fig. 4.6). Finding ways to encourage return of birdwings to Brisbane continues to be a key objective for Network members for the decade from 2010 (Sands 2008) and can only be achieved by: (i) restoring patches of habitats in Brisbane suburbs, and planting adequate numbers of *P. praevenosa,* and (ii) rehabilitating suitable corridors by planting rainforest trees with the food plant vine. A longer-term objective is to promote movement of birdwings through corridors, and to establish breeding colonies between Brisbane, the Gold Coast and Sunshine Coast.

At least one major Core Recovery Site planted with sufficient numbers of *P. praevenosa* and managed for weeds is required for the recovery of birdwing butterflies in each sub-bioregion. For example at least three sites are needed in Brisbane, on the Sunshine and Gold Coasts, and at the base of the Scenic Rim (and foothills of the Macpherson Range), particularly when closing the gap through increasing connectivity in the distribution of the Richmond birdwing from the north and south of Brisbane. Ideally Core Recovery Sites should be spaced within about 30 km of other sites planted with *P. praevenosa* to ensure they lie within the predicted flight range of a gravid female birdwing.

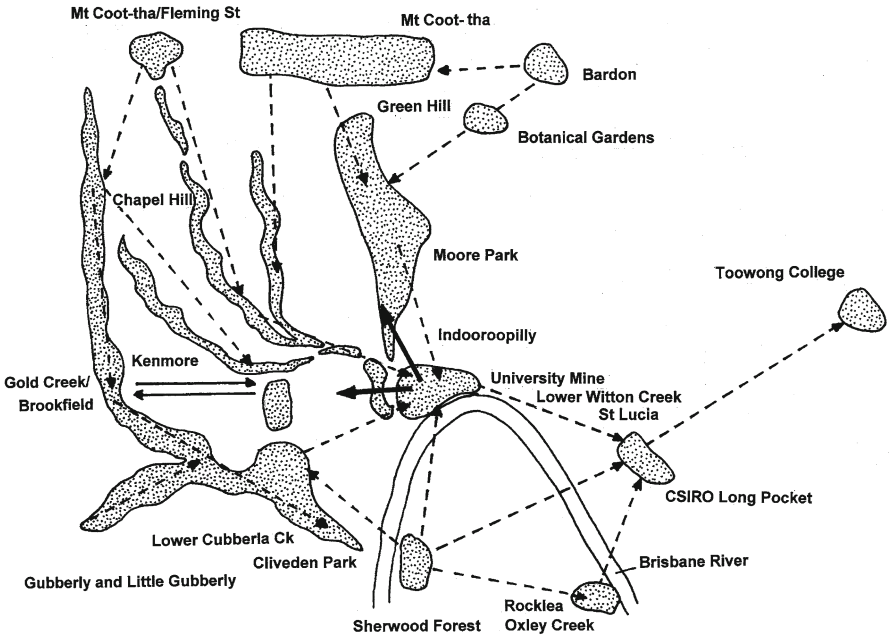

Fig. 4.6 The corridor planning habitat restoration for *O. richmondia* for the western suburbs of Brisbane (Based on map by R. Bull)

4.8 Cultivation and Distribution of the Birdwing Butterfly Food Plants: A Core Recovery Activity

For some time the propagation of the lowland food plant had been considered an important step towards recovering the Richmond birdwing (Sands 1962)**.** The first large-scale propagation of *P. praevenosa* began after 1990 when Moffatt and Sands proposed that the vine could be raised in nurseries in sufficient numbers for planting in school yards, gardens and at bush regeneration sites. Large scale production of vines was seen as a way to compensate for the declining numbers of wild food plants, lost from bushland sites, and to provide a greater abundance of vines closer to urban areas, to encourage the birdwing to breed. Soon afterwards Moffatt provided several schools near Lismore, NSW with the vines to attract the birdwing butterfly into the school grounds. These schools were not far from national parks where the birdwing colonies and natural vines had remained intact, and within a few years the vines he had distributed were large enough to attract the butterflies. This move triggered the expanding interest by students and the community in northern NSW, and later spreading to Queensland. Moffatt was the first to notice on vines in his garden, that the birdwing larvae were cannibalistic, especially when soft leaves were in short supply, and he noted that instars 1–3 readily fed on eggs and larvae and that larger larvae even attacked pupae.

Moffatt provided Balunyah Nursery at Coraki, northern New South Wales, with some of the vines which initiated the larger scale propagation programme. Staff at Balunyah developed methods for propagating the two indigenous species, *P. praevenosa* and *P. laheyana* and, guided by the Manager Scott Heard, by 1993 the Balunyah Nursery had sold 3,500 vines to schools and the community. Within three more years, more than 15,000 *P. praevenosa* vines were sold to the public. The Nursery became well known for its Birdwing Butterfly Vines and the excellent quality of plants. Five other nurseries in northern New South Wales soon followed by propagating *P. praevenosa,* and by 2001 it was estimated that more than 32,000 vines had been sold to the public. Balunyah Nurseries also developed methods to grow the mountain vine, *P. laheyana,* but sales of this vine did not prove to be very popular. However, some colour, size and flower forms were found that could have been of gardener interest, including one discovered in the ranges north of Kyogle, and nick-named ‘Birdwing Buttercup’ by the nursery staff. The impressive yellow flower variety (figured by Sands and Scott 2002) had the potential to become a horticultural novelty as well as a mountain food plant for the birdwing butterfly. Further cultivation of *P. laheyana* was not attempted until about 2005 when Hugh Krenske began cultivating the vine at Toowoomba, for planting on the Main Dividing Range.

In Queensland, stocks of *P. praevenosa* were easily propagated in nurseries and distributed to the public from the late 1990s. The vines originated from various localities in northern NSW, mostly Nerang and Tamborine Mountain, Queensland, often selected by propagating seeds from individual plants that produced healthy capsules. In Queensland, Arthur and Narelle Powter began a major project to propagate *P. praevenosa* following the successes in northern New South Wales.

Powter attended a field day at the Beerwah Field Study Centre where Sands talked about the plight of the Richmond birdwing in south-eastern Queensland, and later observed a small colony of the birdwing butterflies breeding on his property at the foot of Mount Mellum, at the southern end of the Blackall Range. He began collecting seed capsules from his wild vines and started to propagate the seeds, and to distribute the vines locally to the local community with help from Caloundra Council. Powter propagated at least 1,000 vines and planted more than 200 in his own garden, where he observed the butterflies build up in numbers, and where they were often found breeding on every vine that he planted. By 2004 the Caloundra Council (later the Sunshine Coast Regional Council), took on a major role with help from Powter and volunteers, by growing *P. praevenosa* and helping distribute the vines to members of the community. Many others became enthusiastic with the concept that the Richmond birdwing could be 'recovered' on the Sunshine Coast. From 2005, several plant nurseries, including that owned by Gary Einam, have continued to cultivate the vine and produce very healthy plants suitable for planting by members of the community.

Following from the work by Powter, on an adjoining property at Beewah, Ray and Pam Seddon grew many *P. praevenosa* and by 2010 they had distributed for planting at least 11,000 vines, including those planted on a trellis (Fig. 4.5c), designed by Ray and built at Mary Cairncross Scenic Reserve, at Maleny. This Reserve has become an important tourist centre, where visitors can view the relatively natural and intact lowland rainforest shrubs, orchids, ferns and trees; they can watch the marsupials and butterflies, and hear many species of rare rainforest birds. Easily viewed by the public are some 'old growth' vines (*P. praevenosa*) where the birdwings breed on representatives of complex stands of vines that are more than 100 years old, now very rare even in national parks. These natural vines help to sustain local breeding by the Richmond birdwing and their habitat is supplemented by more than 30 vines that have been planted on trellises since about 2005. The Reserve has become one of the most important breeding sites for many species of rare rainforest butterflies and it contributes significantly to recovery of the Richmond birdwing in south-eastern Queensland. Close to Brisbane from 2005 onwards, Richard Bull at Indooroopilly, and Dale Borgelt and Prof. Graeme Wilson, Manager of Moggill Creek Catchment Group's nursery at Gold Creek Reserve, propagated several hundred *P. praevenosa* for local distribution.

In response to publicity, people working on restoring riparian rainforest west of the Border Ranges, reported a significant site for breeding populations of the Richmond Birdwing along Armitage Creek, Canungra. The extensive area with mature *P. praevenosa* vines was considered to be a critical habitat on Commonwealth-owned land for the butterfly in the area. Within a year of clearing of the lantana by Green Corps, the lush growth from the base of the *P. praevenosa* vines began to attract egg-laying birdwings and later supported significant populations of larvae. By 2000, the site had been replanted with a range of native plant species including more than 50 additional *P. praevenosa* vines. The Canungra site later became the most significant breeding area for dispersal of populations north and south of the Gold Coast and into the mountains of the border ranges.

Most of the initial difficulties with propagation of *P. praevenosa* were overcome by nurseries between 1990 and 2010; however these were followed by three simple and important recommendations accompanying protocols (Appendix 1) for planting the vines: (i) young tube stocks should not be used for planting directly into the ground, as substantial mortality commonly ensues, (ii) potted plants grown in large (12 cm or more in diameter) pots should be at least 2 years old before planting, and (iii) dolomite (10 % by volume) should be mixed with soils used to back-fill around the roots when planting in the ground. By 2011, approximately 58,000 vines had been cultivated by nurseries and distributed for planting by the community. Quality vines of *P. praevenosa* have continued to be cultivated by several nurseries on the lower Sunshine Coast and Gold Coast, Queensland and in northern NSW, while the methods for planting out vines into their final positions have overcome the earlier slow growth and wasteful mortality of the vines. By pooling experiences from growers, most limitations to obtaining healthy growth were overcome and only the effects of prolonged drought have continued to have uncertain and detrimental effects on cultivation of the vines. *P. praevenosa* is now regarded as easily propagated but the planting methods require careful attention, not unlike those for many other rainforest plants. Once the vines are planted in their final place, the needs (moisture, nutrients, dolomite mix for backfill, drainage, light etc.) of most rainforest plants are not too dissimilar.

The culture of Birdwing Butterfly Vines has been a strictly not-for-profit exercise, mostly due to the time required (more than a working minimum of 2 years) before the vines are ready to plant out in the ground. As a protected species of plant, the propagation of vines in Queensland requires the issue of permits, or endorsement on permits issued by the State agencies with tags bearing permit numbers: obligations many nursery owners felt were too time consuming for a small financial return. On occasions concerns were expressed by members of the community that they were unable to obtain local provenance vines – believing that each small catchment area might have once had vines with special inherited characteristics. Originally a forestry term, 'local provenance' was not earlier understood in relation to the genetic and phenotypic influences on plant architecture, or suitability for certain soil types. Eventually, most of these concerns were addressed when preliminary studies showed that, while extensive variation could be seen in leaf form, colour of flowers, frequency of flowering and seed capsule formation of *P. praevenosa*, there was no evidence for unique genotypes in any of the populations studied using readily available molecular methods.

In the last 20 years, propagation in Queensland of *P. praevenosa* has stimulated considerable interest among nurserymen, towards growing a range of food plants for the larvae of subtropical butterflies and moths. Butterfly Gardening has become a popular technique for urban gardens and articles now appear in well-known gardening magazines, for Subtropical Gardening (Plant 2012), as well as several books that focus on this subject, for example the books by McDonald (1998) and Schwenke and Jordan (2005). The need for butterfly food plants has challenged many nurserymen and garden enthusiasts, to find and grow other rare plants that were previously considered to be "too hard" to cultivate. Cultivation of *P. praevenosa* is likely to

continue as a means of attracting the Richmond birdwing to return to breed in areas where it has become extirpated, to plant in corridors for restoring connectivity between breeding patches, or as a way of reducing the rarity of both butterfly and its food plant. More plant nurseries are always needed to fill the demands for readily available and inexpensive 2 year-old (or preferably slightly older) *P. praevenosa* vines, and to have stocks of potted vines readily available to the public for planting in gardens, and to community groups involved with bushland rehabilitation. Each such nursery must be responsible for obtaining the correct permit, with the relevant permit number attached to the pots or accompanying every vine sold.

4.9 Other *Aristolochia* Species as Possible Food Plants for the Richmond Birdwing

Occasionally plant nurseries have marketed *Aristolochia acuminata* (= *A. tagala*) as a food plant for the Richmond Birdwing, unaware of the toxic properties now known when the females deposit their eggs on young leaves of this plant (Straatman 1962). Curiously although larvae will develop by feeding on its leaves, eggs of the Richmond birdwing and possibly pupae attached to the leaves may suffer when toxic compounds migrate into the tissues of eggs or base of the pupae. This does not occur when the northern birdwings *(Ornithoptera euphorion* and *O. priamus*) oviposit or pupate on the leaves of their indigenous and common food plant, *A. acuminata*. Plant nurseries in the subtropical regions have therefore been asked not to cultivate this tropical vine whereas in northern Queensland nurseries are encouraged to grow and sell *A. acuminata* as a food plant for *O. euphorion*. Experiments with the low scrambling and woodland species, *Aristolochia meridionalis* and *A. pubera,* are continuing. Although both the vines can be grown in pots from seeds, methods to germinate the seeds, maintain the vines in large pots and find out suitable soils for their sustaining growth have not yet been refined. Other species of Australian *Aristolochia* and *Pararistolochia* (such as *P. deltantha*), from northern Queensland and outside of the natural range of the Richmond birdwing, have not yet been evaluated for suitability as subtropical food plants for this birdwing.

There appears to be no appropriate substitute for using the subtropical lowland vine, *P. praevenosa* as the most suitable food plant for cultivation and distribution for planting on private and public land as a means to provide sufficient food plants to 'bring back' the Richmond birdwing to breed over its original range in southeastern Queensland and northeastern New South Wales. It may be possible to find more suitable 'strains' of this vine for cultivation, for example, forms with softer and more palatable leaves, more suitable for young birdwing larvae, or to select stocks that will survive better through the drought periods now expected to increase over the next decades. Provision of suitable food plants will remain a major focus of the conservation programme.