

Chapter 2

The Richmond Birdwing Butterfly

2.1 The Richmond Birdwing: Distribution and Decline

In the early 1900s, the Richmond birdwing (at that time referred to widely as ‘the Trojan’ in northern New South Wales, and more formally considered generally to be a variety of *Troides priamus*’ for example by Rainbow 1907), was known to have had a patchy distribution from near Grafton and the Clarence River, New South Wales, to Maryborough, Queensland (Illidge 1898; Rainbow 1907; Waterhouse 1932; Common and Waterhouse 1981) (Fig. 2.1), thus incorporating a range far beyond the current distributional extremes for both the butterfly and its major food plant. The historical distribution was likely to have been limited in subtropical Australia, linked with the distribution of its lowland food plant, *Pararistolochia praevenosa*, with both food plant and butterfly dependent on the restricted climatic envelope suitable for their growth, development and reproduction. By the early 1930s the butterfly had become scarce at the northern and southern parts of the range, prompting Waterhouse (1932) to state: ‘Very few specimens are now to be found at Maryborough and Gympie..., or on the Clarence River...’ (Fig. 2.2). By 1959 the last natural breeding colony near Mary River Heads was cleared of birdwing food plants for urban development (Sands and Scott 2002) and by the mid 1980s, the small birdwing habitat patch with rainforest and food plant vines near Rainbow Beach was observed being destroyed during logging operations. In 1984, a male birdwing was seen near this site by the late Murdoch De Baar and Sands: it was probably the last individual seen in the former northern habitats between Gympie and Maryborough. Birdwing distribution had by then contracted to about two thirds of the original range and the numbers of habitat patches supporting the butterfly were declining rapidly. A recent (2011) report of birdwings seen on Clarence Peak near the southernmost recorded range margin requires confirmation, but some apparently suitable plant communities remain to the east of Grafton that may continue to support the butterfly and its food plant in some remote areas. Detailed surveys are needed to determine whether this is so.

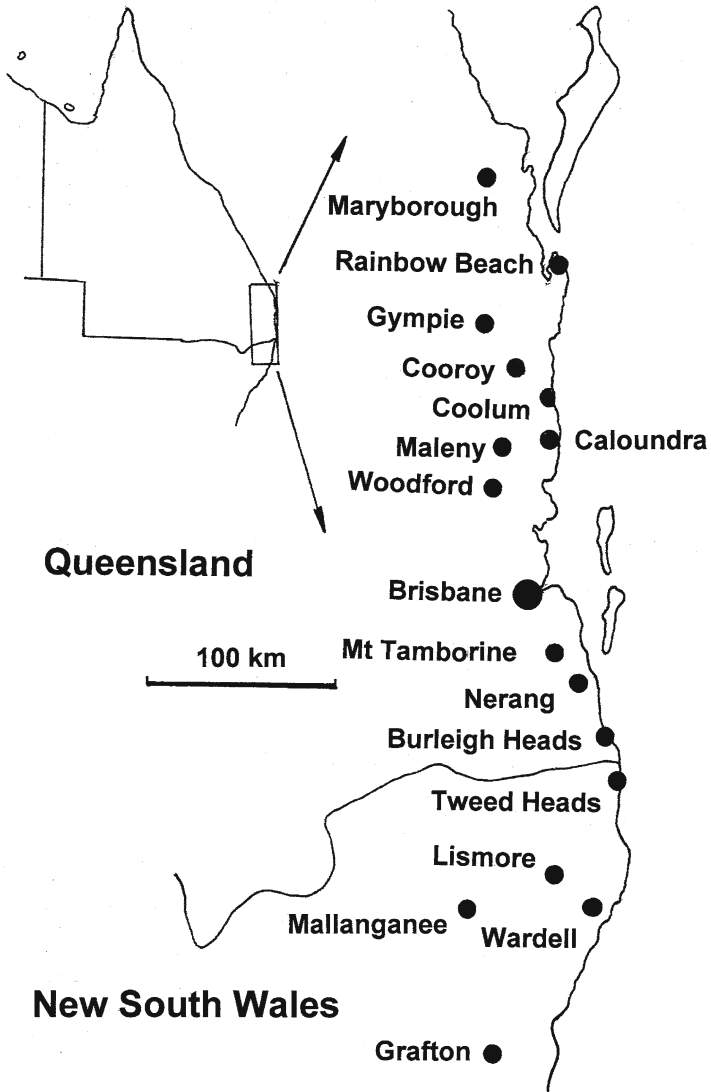
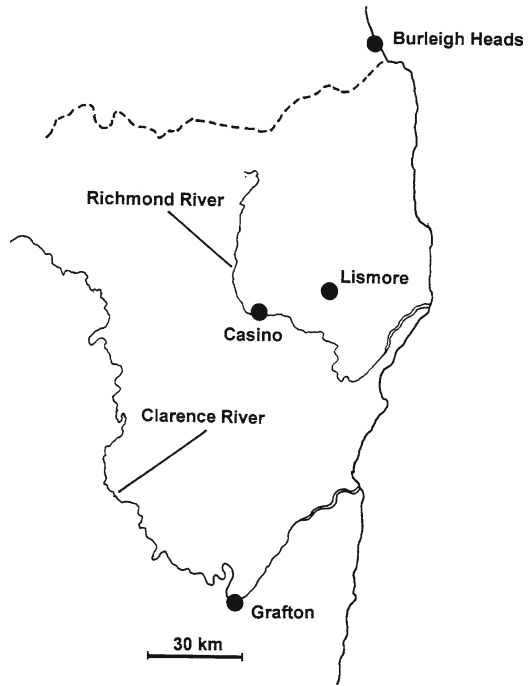


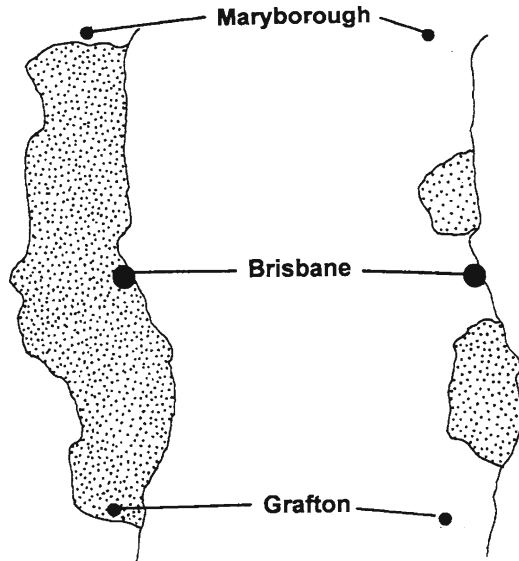
Fig. 2.1 Map to indicate localities of some key places that are mentioned in text

Fig. 2.2 Map to indicate localities of some key places within the area of New South Wales shown in Fig. 2.1



The type locality for *P. praevenosa* is the Clarence River, NSW (Parsons 1996b incorrectly cited Clarence River as in Queensland). Barrett and Burns (1951) also mentioned the Clarence River as the southern limit of the birdwing, as did a report of a birdwing seen on Susan Island, near Grafton in the 'early 1950s', and northern range contractions of *O. richmondia* were discussed by Sands and Scott (2002), who showed the last reported northern sightings of adults and several vines of *P. praevenosa* were at Mary River Heads in 1959. That birdwing habitat became a residential area and by the late 1960s, no food plants or birdwings could be seen in the area. The western limit of the birdwing is not known but it definitely occurred, based on several sightings of adults by the late Jack Macqueen, on the escarpment of the Main Divide and at Middle Ridge near Toowoomba, but the local whereabouts and identity of its food plant was unknown. The Richmond birdwing became rapidly extirpated from the northern, southern and central former range between 1960 and 1990, due mostly to habitat disturbance and fragmentation. At the time that conservation measures were considered, its range had been divided into two discrete parts – to the north and south of Brisbane (Fig. 2.3).

Fig. 2.3 Historical (*left*) and recent (*right*) distribution range of *O. richmondia* in eastern Queensland and New South Wales



In the central part of its range near Brisbane, the Richmond birdwing had been reported occurring in large numbers in the city in 1870 (Illidge 1927). Rowland Illidge (1924b), an early Queensland naturalist, also noted that the Richmond birdwing had declined in abundance since the early 1900s at Bulimba, a Brisbane suburb. According to Hughes (2006) very few breeding sites for the birdwing remained intact after the 1940s in Brisbane's Western Suburbs, and most suffered from clearing of rainforest along water courses, and wherever riparian areas were to be used for farmlands. Declines in birdwing sightings in Brisbane continued to be reported until the 1960s, prompting a suggestion by Sands (1962) that the butterfly's food plants might be planted in gardens, to encourage breeding to counter the declining birdwing numbers. In an address to the Royal Zoological Society of New South Wales, Sands proposed that Brisbane residents could follow the lead taken by people in Townsville, northern Queensland, who successfully attracted the Cairns birdwing into their gardens, by planting a local food plant (*Aristolochia acuminata*), a vine that was locally obtainable. In the 1970s, Gary Sankowsky at Mount Tamborine and Tony Hiller at Mount Glorious encouraged growing native food plants for butterflies, including those that had become uncommon. The plants included the lowland birdwing butterfly vine (*Pararistolochia praevenosa*), and Sankowsky and Hiller both generously made plants, seeds and cuttings available for propagation by Sands at Chapel Hill in Brisbane. Sands' garden contained a fragment of rainforest along a stream originating on Mount Coot-tha. With advice from Dr Len Webb and Geoff Tracey, rainforest experts and colleagues from CSIRO in Brisbane, many rainforest plants and birdwing butterfly vines were planted there in order to provide resources for birdwings and several other local

and rare butterflies. That foundation advice had a major influence on the subsequent directions taken for restoring habitats for Richmond birdwings in south-eastern Queensland and in north-eastern NSW. Meanwhile, in the mid 1980s the few remaining birdwing habitats near Brisbane, notably one at Mount Nebo and another at Bardon, were cleared of their birdwing food plants. Elsewhere, the natural breeding sites near Caboolture north of Brisbane, and those near Nerang south of Brisbane, were also cleared for development. Further north and at about the same time, birdwing and food plant extirpations were confirmed at Pomona, in Noosa National Park, along the Mary River, and to the south, between the Richmond River and Grafton in NSW.

The recent distribution of the Richmond birdwing extends in a south-western direction along ranges from Kin Kin, Queensland to Wardell, NSW but most coastal colonies in Queensland are badly fragmented. Within this range, most permanent breeding sites have been north of Brisbane, from Mount Mee on the D'Aguilar Range to the Blackall and Conondale Ranges, and south of Brisbane from Ormeau to the Queensland-NSW Border. Occasional breeding occurs in the western and eastern suburbs of Brisbane and a sighting in Brisbane City in 1966 was reported by Orr and Kitching (2010). The last permanent breeding sites in Brisbane suburbs were destroyed by housing developments near The Gap, by clearing of riparian rainforest at Bardon in the mid 1980s, and from a housing development at Chapel Hill in the late 1990s. Breeding in the fragments of peri-urban habitats has been temporary, due to the insufficient numbers of food plants and inbreeding problems (see Orr 1994). Sporadic re-colonisation was thought to have resulted when females immigrated from the D'Aguilar Range to the northwest to colonise the western suburbs of Brisbane. One recent report of breeding next to the Brisbane River occurred in the late 2000s near Indooroopilly in an area where food plants were cultivated by local resident, Richard Bull.

2.2 Biology

Adult Richmond birdwings are attracted by flowers of many indigenous and exotic shrubs and trees (see Hughes 2006), particularly if red or white, and feed on nectar of flowers from a wide range of plants. The flowering periods of many suitable nectar plants (Table 4.1, p. 83) are seasonal and may sometimes be variable but indigenous plants that flower in spring (for example, *Hymenosporum flavum* (Hook.) F. Muell.) soon after over-wintering pupae have emerged, tend to attract most butterflies. In summer and autumn the flowers of all eucalypts are popular, and adults of both sexes will travel some distance from the breeding sites to feed, particularly when freshly emerged, to visit gardens. Flight is often at tree-top level, 30 m or more above the ground, but both sexes will come within a few metres of the ground when feeding at flowers. Feeding occurs mostly during sunny periods early in mornings (08.00–10.00 h) or in the afternoon until

sunset (15.00–18.00 h) and both sexes if freshly emerged, will share the flowers on one plant without males harassing feeding females. Males are not sexually mature until 2–3 days after pupal eclosion and during this period show little interest in mating, whereas females are sexually mature immediately after eclosion. After first feeding, males will spend short periods finding circuits and corridors for flight and eventually will set up ‘waiting perches’, resting on sunlit leaves with wings closed during the warmest mid-day periods. Males will live for about 20–30 days and females 25–45 days, depending on availability of nectar and avoidance of desiccating low humidity. Adults have not been seen feeding at wet sand, a behaviour well known in many tropical butterflies including the Rajah Brooke’s birdwing (*Trogonoptera brookiana* (Wallace)) in Malaysia, in which freshly emerged males imbibe moisture and obtain sodium, needed to mature their reproductive systems.

After reaching maturity, the flight of males becomes more rapid, continuing for periods of 10 minutes or more, as they claim territories and flight corridors when searching for a mate, or briefly intercepting and engaging in combat other males if these are potential mating competitors. Males will attempt to drive away other large butterflies, regardless of colour or similarity, and may chase moderately-sized (up to about 20 cm) birds when they enter their territories, before returning to ‘their’ perch. Male birdwings usually patrol at the edge of sunlit rainforest canopies but sometimes patrol hilltops, a behaviour common in many species of butterflies, and with representatives from all Australian families, including other Papilionidae. Between patrols adults rest on foliage for 5–10 minutes in sunlit positions that give them maximum visibility when searching for females. They will compete with other male birdwings, especially when a female visits the hill, and ‘claim’ flight corridors of 50 m or more between periods of settling on the canopy. Male birdwings are not known to patrol on hilltops when they are more than 3 km from breeding sites. When freshly emerged from a pupa, and if disturbed when the wings are insufficiently hardened for flight, adult birdwings sometimes perform a defensive aposematic display, by bringing the fore wings forward and curving the abdomen in a way similar to that in *O. priamus*, which is said to mimic a wasp in the act of stinging (Common and Waterhouse 1981).

Females usually mate only once and often immediately after eclosion but according to Rosemary Booth and Jacqui Seal (pers. comm.), some individuals are known to have mated twice in captivity. No speragis is produced. After mating a female birdwing will reject males that approach and can take avoidance action by flying rapidly or low into undergrowth. The courtship process is often prolonged, with male and female alternating their positions above one another – often in almost stationary positions, and hovering for some time prior to mating. Mating usually continues for several hours with both sexes opposite under a leaf while holding wings closed. Hand-mating was successfully manipulated when outcrossing was required for inbreeding depression studies (Chap. 8, Fig. 2.4).



Fig. 2.4 Ovipositing female of *O. richmondia*: note conspicuous thoracic red patch (L. Forster)

2.2.1 *Effects of Plant Nutrients on Larval Development and Adults*

The distribution of *Pararistolochia* vines, and several other rainforest plant genera in Australia and Papua New Guinea, indicates the dependence of birdwing immature stages on nutrient-rich food plants that grow on nutrient-rich soils, particularly basaltic soils or volcanic alluvium such as that surrounding the volcanic core of Mount Warning (Fig. 2.5). Although a number of species of *Ornithoptera* (including *O. euphorion*, *O. priamus*) feed readily on both *Pararistolochia* spp. and *Aristolochia* spp., larvae of the rarer birdwings from Papua New Guinea (such as *O. alexandrae*, *O. meridionalis*, *O. paradisea*) are specifically adapted to one or few species of *Pararistolochia* and depend on the nutrient-rich vines growing on volcanic soils. It is not only leaves of the food plants that are consumed by birdwing larvae, and many of the New Guinean and Australian species, including *O. richmondia*, *O. euphorion* and *O. priamus*, will feed on buds, flowers, seed capsules and stems, sometimes ring-barking or severing the vines. In the case of the New Guinean *Ornithoptera goliath* Oberthür, a very large birdwing (female wingspan to 27 cm), its maturing larvae will truncate the old and woody stems after feeding on the leaves and before pupating. It is also likely that stem feeding in some species of *Ornithoptera* is related to the nutrient demands of larvae. While the ecological significance of stem feeding by maturing larvae of birdwings is not understood fully, it is thought to be a way of: (i) utilising higher concentrations of solids and less moisture than in leaves, or (ii) taking advantage of nutrients in the interrupted sap flow.

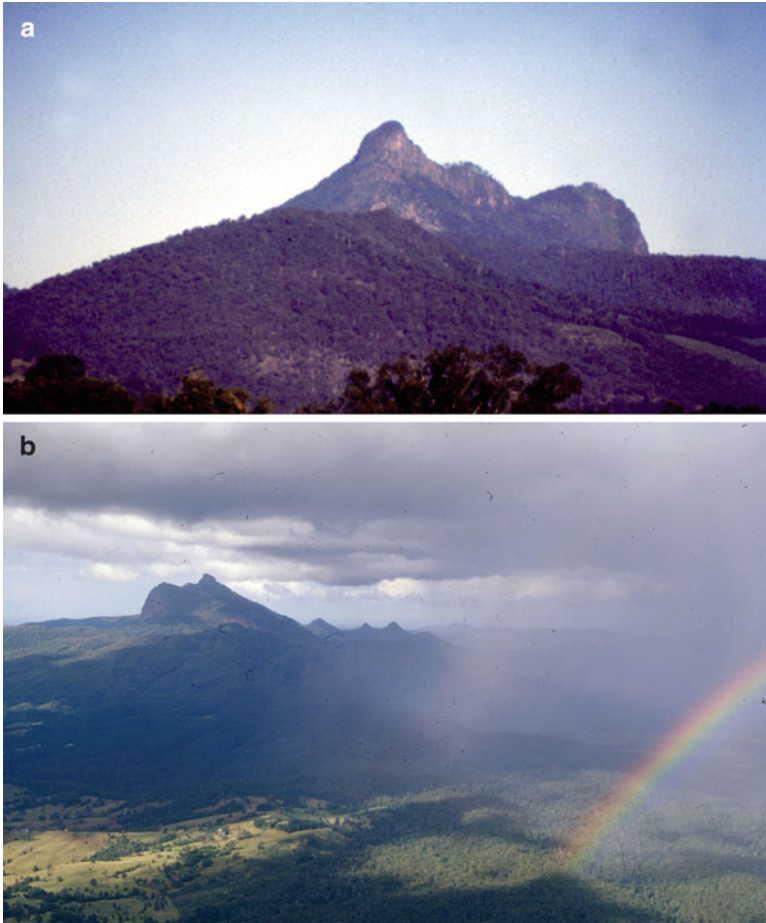


Fig. 2.5 Mount Warning, New South Wales: (a) from east; (b) from west

Nitrogen concentration in food plants of Lepidoptera is known to influence numbers of instars, rates of development in larvae, and size and fecundity in adults of Lepidoptera (Taylor 1984; Taylor and Sands 1986). In preliminary experiments, to determine the effects of nitrogen in the food plant (% dry weight of leaves measured as by Williams and Twine 1967) on larvae of *Ornithoptera richmondia*, fertiliser with three different levels of nitrogen (N) was added to potted food plants (*Pararistolochia praevenosa*) and the leaves fed to newly-emerged larvae (5 larvae each N treatment) until pupation. The trial compared effects of larvae fed fertilised plants with larvae fed unfertilised control plants and aimed to determine: (i) larval development times and numbers of instars, (ii) ovariole development in newly-eclosed adult females, (iii) pupal weight and adult size (fore wing length) and (iv) adult longevity. In

each trial fertilised and unfertilised vines both had actively-growing terminal shoots growing up stakes.

The significance of results was limited by low replication. Insufficient numbers of each sex and mortality limited the number of larvae reaching the adult stage, but trends based on means and measurements from each experiment indicated that: (i) more first instar larvae survived when fed soft leaves with high N concentrations than larvae fed unfertilised vines with firmer leaves, (ii) larval development times were more rapid on fertilised vines (with high N) than unfertilised controls (with low N), (iii) the numbers of instars of larvae fed plants with high N was always 5, compared with occasionally 6 instars completed by low N control larvae, (iv) ovariole development in newly-eclosed females adults indicated more advanced oocytes were present in adults fed high N than in low N controls, (v) pupal weight was heavier when larvae had fed on fertilised vines, and the resulting size of both sexes (fore wing length) was greater than those fed unfertilised vines, and similar to maximum fore wing lengths of adults seen in the field, and (vii) adult longevity was increased in females given high N in food plants, but not in males. The preliminary outcomes suggested substantial impacts of food plant quality.

2.3 Times of Appearance, Dispersal, Population Changes and Migration of Adults

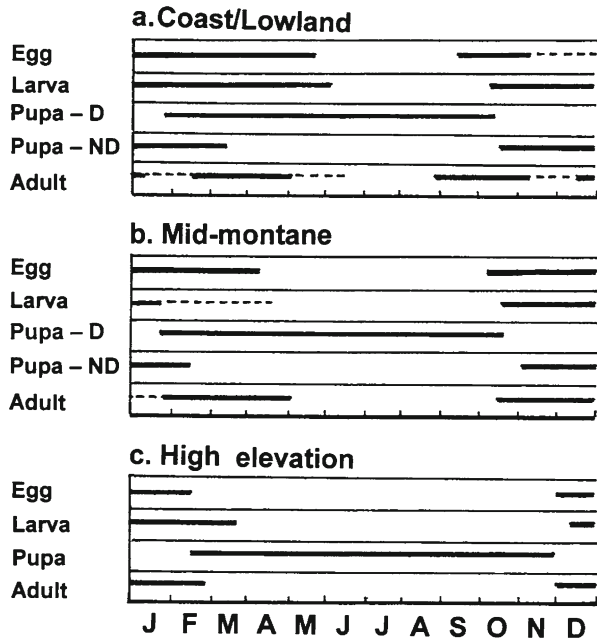
At all locations the rates of development of immature stages vary with season and for the larvae, the quality (reflecting texture and nitrogen content of leaves, as above) of the vines available. During warm weather, food plants on nutrient-rich soils (such as basalt) rapidly take up more nitrogen during moist weather and the development of the larvae feeding on these plants is much more rapid than during cool weather and when plants are growing on nutrient-poorer soils (such as alluvial soils or sand). The influences of temperatures, soil moisture and nutrients, day length and food plant quality provide the primary cues for times of appearance, dispersal, population changes and the occasional migration of adults.

Considerable overlap occurs across generations in warmer months, particularly if adequate rainfall prevents the problems caused by prolonged diapause in pupae in spring and summer. However, little is known of the way diapause regulates emergences except when day length increases, temperatures rise and rainfall in late winter triggers the development of pupae followed by adult emergences in spring. The rate of immature development is always dependent on temperatures but it also relates to the quality of the food plant. During prolonged moist weather, *P. praevenosa* produces robust growth of climbing stems and the alternate leaves containing high nitrogen and other nutrients expand more rapidly. Instars 1–3 receiving an increase in nitrogen concentrations develop more rapidly, and the larvae become larger than when the larvae are fed on less nutritious leaves. The resulting pupae and adults are larger and female fecundity is greater when larvae have consumed leaves with higher

levels of nitrogen. Moreover, oocyte development takes place more rapidly as the stored ‘fat body’ increases the rate of development of eggs prior to oviposition.

The pattern of seasonal development differs in relation to climate and elevation, as shown in Fig. 2.6, with characteristic contrast between lowland and higher elevation localities.

Fig. 2.6 Patterns of seasonal development of *O. richmondia*: incidence of different growth stages by month (initial letters from January to December) in (a) coastal and lowland regions; (b) mid-montane sites; (c) high elevation sites (D, diapausing; ND, non-diapausing)



2.3.1 Lowland and Coastal Localities

At coastal localities where the food plant is *P. praevanosa* there are two or three annual generations of *O. richmondia*, depending on spring rainfall frequency and temperatures. In years with an average to above normal rainfall, and higher than average temperatures, most overwintering pupae break diapause, and produce adults from September (rarely August) to mid October. Eggs deposited in early spring develop and emerge as adults in December to February, providing the second generation. Eggs deposited by these adults develop rapidly and pupae will eclose from March to April, while others enter diapause and overwinter as pupae. In dry seasons eggs deposited in late spring and larvae develop slowly, producing adults from February to March, and overwintering pupae may not produce adults until November through to the following January. On the coast, a spring emergence of adults (September–October) normally follows break in diapause in overwintering pupae, and is sometimes followed by a second emergence mid-year (December–February), while one generation always occurs in late summer and autumn (February–March).

2.3.2 *Lower Slopes and Mountains*

Two generations are usual, adults occurring from November to January and those of the second generation occurring from February to March. On the rare occasions when breeding on *P. laheyana* persists at higher elevations only one generation occurs at elevations above 600 m, when pupae survive winters.

2.3.3 *Migrations*

The cues for adult dispersal or occasional migrations by the Richmond birdwing are not understood fully, but observations have shown that females will usually leave a breeding site soon after they emerge and, if suitable sheltered flyways are available (for example in rainforest corridors or forested watercourses) adults will use these to move to other sites. This appears to be an entrenched behaviour pattern and has been observed in some other Australian butterflies, for example *Cressida cressida*, as likely to counter inbreeding depression (Orr 1994). Males are less likely to disperse and will set up patrolling sites soon after feeding. Annual population changes in undisturbed habitats are linked to climatic variation and the responses to food plant growth and phenotypic plasticity.

In South America, increases in abundance and migrations are known to occur in at least one aristolochia-feeding butterfly. In some years, *Battus polydamus archidamas* (Boisduval) undergoes 'population explosions'. Hundreds of adults have been seen flying out into the Pacific Ocean from the western coast of Chile, and later their bodies observed washed back onto the coast and beaches (Pena and Ugarte 2006).

On rare occasions broad scale migrations of Richmond birdwings from the breeding sites have followed increase in numbers benefitting from high food plant quality (Sands and Scott 2002) and this phenomenon possibly led to the earliest reports of migrating Richmond birdwings seen in Brisbane: '...in the year 1870 it occurred in very great numbers in the town, and boys were chasing and capturing many.' (Illidge 1927). These migrations of large numbers of both sexes of *O. richmondia* have occasionally been observed on the mountains of the Queensland-NSW Border Ranges followed by migrations down the slopes. At Cudgen, NSW in April 1969, Greg Newlands observed migrating adults flying in a north-easterly direction towards the coast and migrations occurred from the Border Ranges and Mount Warning, and from Tyalgum Tops near Murwillumbah in January, 1994 (Sands and Scott 2002). From mid-December 1993 to early January 1994, numbers of adults were seen (G. May) at the edge of rainforest between The Pinnacle and the Limpinwood Nature Reserve, and at about the same time hundreds of Richmond birdwing adults were observed (M. Houston) at Christmas Creek, on the western side of the Lamington Plateau, Queensland.

Many people provided valuable observations about migrations of *O. richmondia* in early 1994. One enthusiastic member of the community made observations of the 1993/1994 birdwing migration from the high country of the Border Ranges: ‘We live at the base of the Border Ranges at Limpinwood and for about 4 days we were literally inundated with adult Richmond birdwings. There is a very steep escarpment behind our property rising to the Border Ranges and the Lamington plateau where the butterflies seemed to be flying in a very narrow strip, and then over our property, all flying in an easterly direction. I have lived in and around the Richmond River and Tweed valleys for 43 years and have never seen such numbers of birdwing butterflies.’ Some migrating adults from the mountains flew towards the west where suitable breeding sites supporting the lowland vine *P. praevenosa* were unlikely to be present.

The cues for developing these large numbers of birdwing butterflies are not known but it appears likely that moist and warm winters are pre-disposing conditions enhancing over-wintering survival of pupae at higher elevations. Such events are indeed sufficiently rare to attract attention and comments such as that above. Many individual butterflies were destined to die after migrating without reproducing and without finding food plants, a behaviour sometimes observed in other migrating butterflies in Australia, for example the Caper White butterfly (*Belenois java teutonia* (Fabricius) [Pieridae]), that often migrates out to sea after southward migration, without any opportunity of reaching a breeding site.

2.4 Life History, Recognition of Early Stages

Many aspects of the behaviour and development of *O. richmondia* are displayed in a commercially available dvd on the butterfly’s life history by Richardson (2009).

After mating, female birdwings begin depositing eggs on the undersides of leaves of their food plant or, rarely, on the stems. Leaves on vines chosen for oviposition are usually sub-apical (30 cm or more from the tip), fully inflated, pale green and not stiff in texture. The soft and often hairy apical and unopened leaves are avoided for egg deposition and sometimes older, firm leaves are selected but they are avoided if softer leaves are available nearby, but females do not oviposit on terminal leaves at times they are expanding rapidly. In the field one egg per leaf is usually laid, less commonly 2 or 3, and rarely more are deposited (Fig. 2.7). Depending on temperature, eggs hatch within 7–13 days, becoming dark a day before hatching when the larva becomes visible through the chorion. Eggs measured by Selvey (2008) were 2.3–2.5 mm in diameter and are at first greenish yellow, becoming pale yellow within a few days and yellow-brown a day or two before hatching. After hatching, larvae first consume their egg shells and then search for a soft leaf where they can commence feeding. Eggs are very prone to predation, including cannibalism by first instar birdwing larvae that have just consumed their own egg shell. There are usually five larval instars (Fig. 2.8) but occasionally six when nutrient concentrations in leaves are low. Ecdysis usually

takes place beneath a leaf of the food plant but occasionally larvae will leave the food plant and remain dormant for 2–3 days on the underside of a nearby shrub or tree until the skin has been cast.

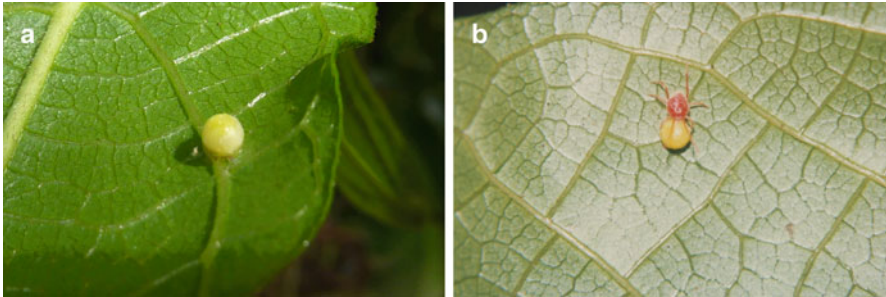


Fig. 2.7 *O. richmondia*: (a) egg on *Pararistolochia* leaf; (b) egg being attacked by predatory mite, *Charletonia* (A. Power)

Heavy rainfall has been observed washing eggs from the underside of vine leaves. However, during dry periods, many first instar larvae starve or are lost when they fail to find a leaf with suitably soft texture on which to commence feeding, or fall prey to ants and other predators. First instar larvae often move from stem to stem for up to 2 days in search of suitable leaves. First and second instar larvae are black with long and soft tapering black spines on all segments except on segment 6, on which the spines are bright yellow and tipped with black, and the head is black. Instars 3 and 4 are black or purplish-brown with similar yellow spines at segment 6, while instars 5 and (when present) 6 are variable in body colour; ranging from black, brown or cream and with spines at segment 6 orange-brown and tipped with black. When fully grown a larva may reach 7 cm in length. Large larvae (instars 4 and 5) of *O. richmondia* are usually uniformly pale grey to dark brown or occasionally black, when found in coastal areas, and are often black in the mountain localities. The differences in colour are not wholly constant. The spines of *O. richmondia* are moderately uniform in appearance: orange-brown tipped black except with the spines at segment 6 basally pale yellow-orange (Fig. 2.8). The head of larvae is dark brown with a yellow ‘collar’ between it and first thoracic segment where the yellow-coloured osmeterium is held when retracted. Larvae extrude this paired tubular organ when alarmed and it produces a volatile odour that is thought to repel would-be predators (Common and Waterhouse 1981; Feeny 1995). When not feeding, larvae rest under leaves where they also complete ecdysis and they will always consume their cast skin before feeding on leaves. Larval feeding continues from 22 to 46 days until the pre-pupal stage (Fig. 2.9), the periods varying with temperatures and nutrient concentrations in the leaves. In contrast, it is interesting that the development of larvae of *O. euphorion* is reported to occur much more rapidly and in as little as 14 days (Common and Waterhouse 1981).

When preparing to pupate, fully-grown larvae usually leave their food plants and move to a suitable shrub or tree nearby. After searching for a day or two for a suitable large leaf, they will eject dark fluid (meconium), spin a thin pad of silk across the underside of a leaf, attach the caudal segment and terminal proleg to the pad with a silken cremaster, and then spin a silken girdle that will support the weight of the larva and eventually the pupa, which is positioned head upward as in other large Papilionidae. Before casting its final skin the larva contracts in length and expands in width and remains quiescent for about 2 days. Final ecdysis takes place rapidly as the larval skin is rolled back and finally ejected by a flick of the terminal segment, before it is re-inserted into the cremaster attached to the silken pad on the leaf. The whole process from cessation of feeding to the final cast of larval skin takes about 3–4 days. When alarmed, all instars of larvae will arch backwards and extrude the fleshy, two-pronged and yellow osmeterium from the anterior end of the prothoracic segment.

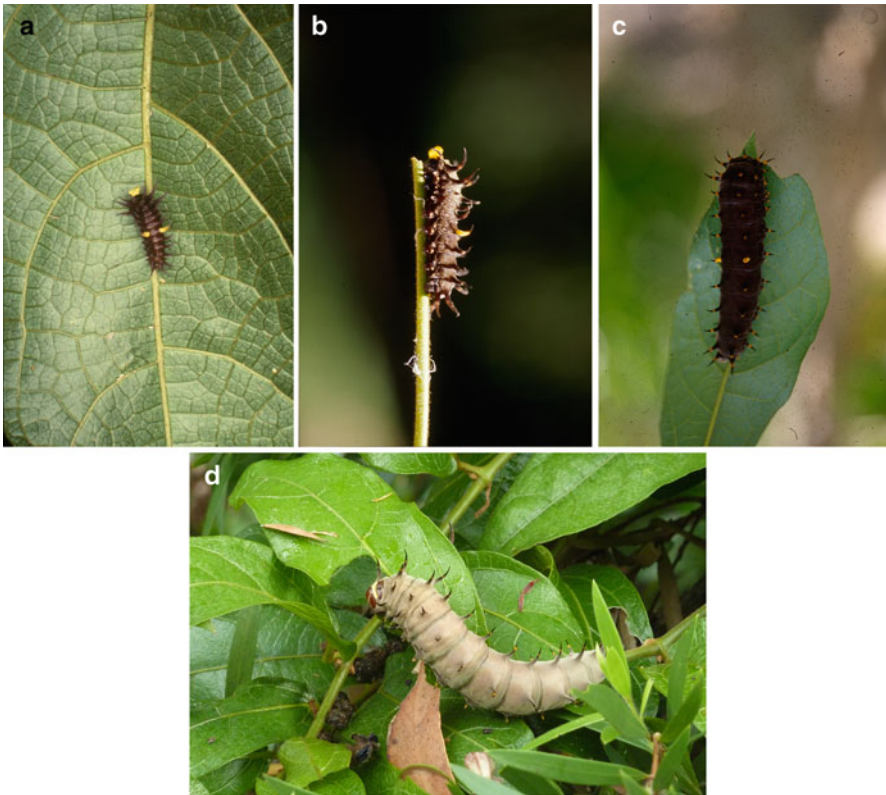


Fig. 2.8 *O. richmondia*, larvae at different growth stages: (a) first instar, with osmeterium extended; (b) third instar; (c) fifth (final) instar, dark form; (d) final instar, grey form (H. Melrose)

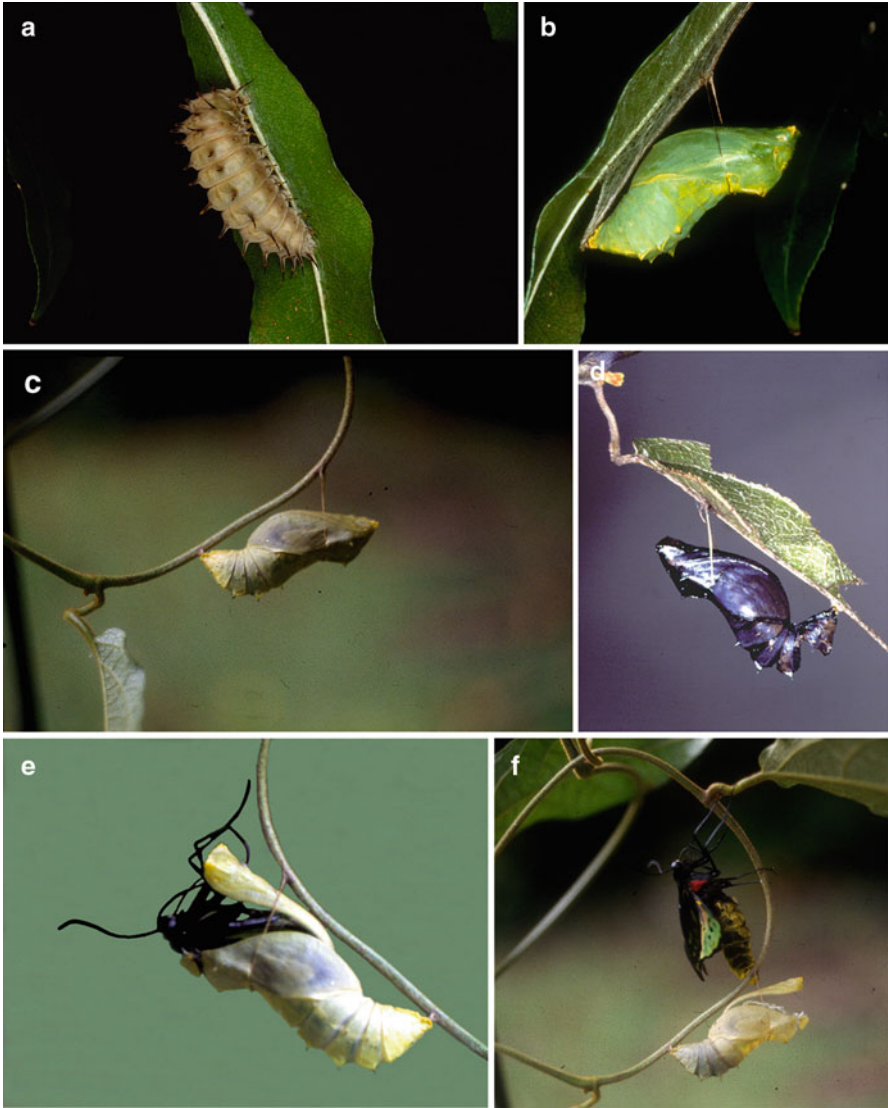


Fig. 2.9 *O. richmondia*: (a) prepupa; (b) healthy pupa; (c) pupa shortly before hatching; (d) diseased pupa; (e) emerging adult; (f) newly emerged adult

Fully-grown Richmond birdwing larvae are very distinctive when compared with larvae of the two northern species of birdwings, *O. euphorion* and *O. priamus*, and not so brightly coloured. The fleshy spines of *O. richmondia* are shorter and less brightly coloured than in *O. euphorion*, as shown in the book by D'Abrera (1971), and *O. priamus* in which larvae are usually black and the fleshy spines orange-yellow on most segments with a brightly coloured cream-orange spine on segment 6.

Some factors causing mortality have been noted above. The most significant mortality factor in the life history of the Richmond birdwing is cannibalism. First instar larvae after having consumed their own chorion will attack and consume any other eggs, regardless of age, when deposited in their vicinity, on the same or on adjacent leaves of the food plant, or when they are in search of soft leaves. One larva has been seen to attack and partly consume eight eggs. All instars are cannibalistic but the first two instars tend to be the stages most frequently seen feeding on eggs, other larvae, especially when in ecdysis, and less commonly when instars 3–5 will feed on pupae.

Larvae of *O. richmondia* are thus very prone to cannibalism both in the wild and in captivity. Inactive larvae are particularly susceptible while they are in ecdysis, and are eaten even when soft subterminal leaves of the food plant are nearby. Cannibalism has a direct effect on the carrying capacity for larvae on *P. praevenosa*, reducing the number of larvae able to complete development on a vine. Presence of many terminal stems with young growth may help to prevent contact between larvae. Larvae while searching for suitable leaves will attack pre-pupae or other larvae while they are feeding. On rare occasions Bob Moffatt (pers. comm.) observed pupae attacked by conspecific larvae in the field, when up to one third of the pupal mass was consumed. The species of food plant appears to influence the incidence and extent of cannibalism by larvae; for example, *P. praevenosa* seems to ‘promote’ cannibalism by larvae but many larvae can occupy one plant of *P. laheyana* without cannibalism, even when larvae are short of food. Moreover, in cage experiments with larvae fed the woodland vine, *A. meridionalis* E.M. Ross (Chap. 3) some larvae ignore the soft leaves and in preference, will attack larvae of their own species!

The pupae of *O. richmondia* are almost always bright green with a cream edge to the wing cases (Fig. 2.9), and very rarely pupae are tinged brown or, even more rarely, yellow (Common and Waterhouse 1981). The description by Rainbow (1907, based on Matthews 1888) of the pupa as ‘amber-brown colour’ probably refers to that of *O. priamus*, as the pupa of *O. richmondia* never corresponds to that descriptor. The duration of pupal development may be temperature-dependent, when pupae are not in diapause between October and January (38–50 days), or variably protracted (127–285 days) when pupae overwinter in diapause. There is a possibility that pupae will enter diapause in warmer months during severe periods of summer drought, an inference based on very limited data on protracted development. Pupae that are formed in autumn will lose weight while over-wintering, when the pupal mass reduces and the pupa become shorter in length. In this way large larvae may eventually develop to produce small adults, particularly after the winter humidity has been low. Pupae are very prone to prolonged low temperatures and desiccation is a major cause of mortality at some locations, especially at higher altitudes. Variation in pupal survival probably contributes to the occasional ‘boom’ and ‘bust’ cycles of adults that sometimes follow periods of suitable weather and abundant and suitable plant phenology. Food plant quality is the other major factor that can cause declines in abundance of birdwings, particularly when drought stress reduces the production of the soft, sub-terminal leaves of *P. praevenosa* needed to support first instar larvae after they have eclosed.

2.4.1 *Natural Enemies*

Eggs of *O. richmondia* are prey to several predators including a range of native ants (*Myrmecia* spp.) and exotic ants (such as *Tetramorium* sp., *Pheidole megacephala* [Fab.]) and in particular, a long-legged red mite, *Charletonia* sp. (Erythraeidae). No parasitoids have been reared from eggs of *O. richmondia* but emergence holes resembling those made by *Ooencyrtus* spp. (Encyrtidae) have been observed on rare occasions. Of these natural enemies only the predatory mite, *Charletonia* sp., appears to respond in abundance with host density; mite numbers certainly increased during periods with the greater birdwing densities between 1995 and 2010. However, the mite is known to be a generalist, feeding also on eggs of other Lepidoptera, suggesting that the response could result from other favourable conditions and not simply higher numbers of eggs. *Charletonia* Oudemans includes around 50 species and is distributed across all continents other than Antarctica. Whilst adults and nymphs are free-ranging predators, larvae are ectoparasites. Most records are of larvae found attached to hosts, and corresponding adults have sometimes been described in *Sphaerolophus* Berlese. The generic synonymy was discussed by Southcott (1991), in whose account 14 Australian species were diagnosed from larvae. Most of these were collected from acridid grasshoppers as ectoparasitic stages, with one reported from larvae of an anthelid moth. Very little is known of host specificity of these mites, but within Lepidoptera, Southcott noted records from Anthelidae, Geometridae, Lycaenidae, Noctuidae, Notodontidae, Pyralidae and Thaumetopeidae. We have not traced any previous associations with Papilionidae.

There have been reports of parasitoids (Hymenoptera and Tachinidae) emerging from the pupae of *O. richmondia* but they must be extremely rare parasitoids in the sub-tropics, and more abundant in the tropics on other species. In contrast, death of pupae from suspected virus and fungal attacks seems to be common.

2.5 Introduction to Concerns and Detection of Threats

The naturalist Rowland Illidge noted (1927) the decline of Richmond birdwings in Brisbane that began in the early 1900s, and subsequently led to its contraction in range, as noted by Waterhouse (1932), and the extinction of populations over more than two thirds of its original range reported by Sands et al. (1997). In south-eastern Queensland where the butterfly was once common, impacts from the clearing of rainforest for farming, forestry and urban development have resulted in fragmentation of the few remaining breeding sites, for example in Burleigh Heads National Park. Until about 1960, the clearing of rainforest patches with *Pararistolochia praevenosa* occurred in many peri-urban areas, and raised concerns with butterfly enthusiasts. They feared that the butterfly, once seen commonly near Brisbane was, together with its food plant, declining in distribution and abundance and in about 1989, people belonging to local environmental groups became concerned by the disappearance of the Richmond birdwing

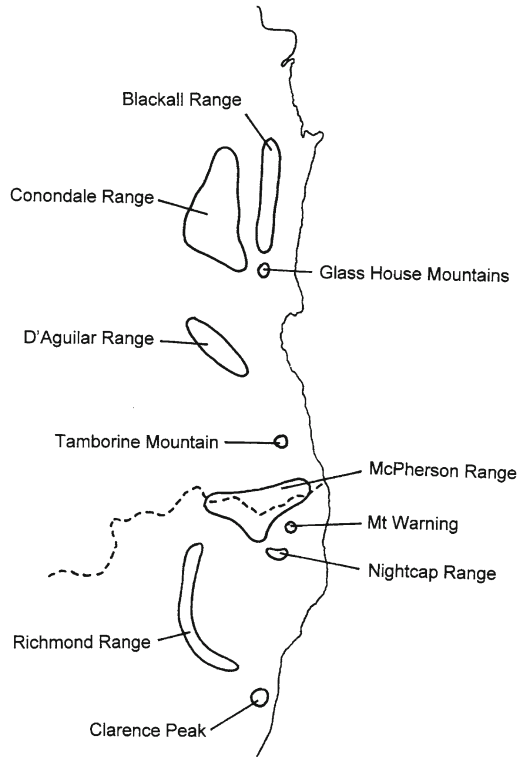
from areas where it had been seen frequently, and they recognised some of the threats that were leading towards local extinctions of the butterfly throughout its range, particularly in Queensland where few breeding areas were protected in national parks.

Weeds caused major problems by invading natural habitats and displacing the understorey vegetation. The habitats for the vine and butterfly that were relatively viable until the 1970s became replaced by weed thickets along the river and stream embankments, sometimes breaking free during floods and leading to collapse and massive erosion of the embankments. Several important soil-binding plants, for example, *Lomandra hystrix* (R. Brown) L.R. Fraser and Vickery, were displaced by weedy grasses and these areas became unsuitable for recruitment by most rainforest plants. Destruction of habitats for the Richmond birdwing and loss of its food plant were the obvious threats identified in Queensland and in northern NSW, invasions by the exotic vines, particularly Madeira vine (*Anredera cordifolia*), Morning Glory (*Ipomoea purpurea*), and Cat's Claw (*Macfadyena unguiscati*), threatened the birdwing habitats and food plants by smothering foliage and constricting the stems by their climbing. These and other introduced vines (see Chap. 3) continue to be amongst the important threats arising to all wildlife in the riparian fragments of subtropical Australia. In addition to the Richmond River, the most extensive areas affected are along the embankments of the Tweed and Clarence Rivers, New South Wales, where the majority of rainforest trees have been cleared to create farmland.

The declines in abundance of Richmond birdwings continued for more than 30 years after the problem of habitat loss was raised by Rowland Illidge in 1927. Since then, one threat that had become apparent to entomologists was the declining abundance of the lowland food plant, *Pararistolochia praevenosa*. While working with CSIRO in Papua New Guinea (1972–1978), Sands' interest in growing food plants for conserving birdwing butterflies broadened from seeing many other spectacular species, and by traditional cultivation of *Aristolochia acuminata* on fences in New Britain, Papua New Guinea (Fig. 1.11, p. 21). These vines were often grown for attracting birdwings including *O. priamus*, to breed in gardens where they could be admired, or used as a 'head-ornaments', as illustrated in their book by Barrett and Burns (1951). In the 1980s while living in Brisbane, Sands noted *O. richmondia* had become extinct from almost all except one or two of the original urban habitats but it continued to be abundant on the Sunshine Coast, and at Burleigh Heads and on nearby ranges. The losses of habitats near Brisbane were mostly from clearing of natural vegetation for urban development.

In Queensland, destruction of rainforest continued in the 1980s in several areas critical for survival of the butterfly habitats, including the Conondale, Blackall and d'Aguilar Ranges (Fig. 2.10), *Eucalyptus grandis* growing in rainforest gullies was seen being felled for timber and the residue was often burnt afterwards to stimulate regrowth of seedlings. These stands were often in the riparian zones where the rare vine *P. praevenosa* could usually be found. One destructive practice was to log the slopes for other eucalypts and dispose of the 'trash' by

Fig. 2.10 Locations of upland areas mentioned in discussion of range of *O. richmondia* (state border indicated by dashed line)



throwing it into the gullies and later burning it when dry, in the belief that this would open up the rainforest and stimulate germination of seeds and growth of eucalypt seedlings. After removal of timber and when some of these areas were eventually transferred for management as National Parks, many of the former habitats had become infested with weeds, including African grasses (such as *Megathyrsus maximus* (Jacq.) B.K. Simon and S.W.L. Jacobs, and lantana (*Lantana camara* L.), in the early 1990s. Repeated burning destroyed many remaining pockets of rainforest with *P. praevenosa*, as well as other fire-sensitive plants, including orchids, and regular use of fires during periods of drought destroyed the growth and recovery of rainforest trees. In New South Wales the 'Big Scrub', the lowland subtropical rainforest growing mostly along the Richmond and Tweed Rivers, was almost completely cleared by logging, for farming and for urban settlements. This was undoubtedly the most serious loss of the rainforest plant communities and its associated animals, both vertebrates and invertebrates. Despite cessation of broad scale rainforest clearing in Queensland and New South Wales in the late 1990s, the rainforests have continued to suffer from displacement by exotic weeds, deliberately-lit fires during periods of plant dormancy and drought, and mining seams of volcanic rocks in riparian habitats.

2.6 History of the Richmond Birdwing Conservation Project

Proposals for increasing the food plant numbers in peri-urban bushlands and gardens were first discussed in 1989 when Sands met Ranger Bob Moffatt from the National Parks Service in New South Wales. They met to discuss an interesting form of a rare Lycaenid butterfly, *Hypochrysops digglesii* (Hewitson), breeding on mistletoes growing on banksias, in a property adjoining the Broken Head National Park and were most impressed with the healthy densities of *P. praevenosa* and how the vines were supporting one of the most stable populations of Richmond birdwings in the State. They were concerned about the future of the Richmond birdwing in both range states, and its chances of surviving the declines in abundance, and how the major threat was the widespread losses of the habitats with old stands of the food plant (*P. praevenosa*). Remote from urban areas a major concern recognised was the on-going clearing of rainforest containing *P. praevenosa* and this called for a review of 'what was being protected' in the remaining rainforest habitats. Very few *P. praevenosa* survived in protected areas of south-eastern Queensland but some 'old growth' (100 years +) examples had been well protected in north-eastern New South Wales, for example, in the Mount Warning National Park and Broken Head National Park. Sands and Moffatt discussed how the threats and declines in birdwing numbers might be offset by growing sufficient numbers of the vines as food plants in gardens, school yards and at bush regeneration sites. This meeting in Broken Head National Park between Sands and Moffatt led to the formation of a Richmond Birdwing Conservation Project. The Project began by gathering information about cultivating the food plants, and planning where they could be planted to attract the birdwings, and also sought to identify the threats and the best ways to prevent their continuing harmful impacts on the birdwing, its habitats and food plants.

In 1994 the Richmond birdwing was listed as a 'protected species' of butterfly in Queensland and subsequently the species was listed as Vulnerable by the State agency. Although a comprehensive dossier was prepared (Sands and Scott 1996) as a Draft Recovery Plan (p. 112), the document was not formally published. This document contained details of the basic biology of *O. richmondia* which, although incompletely understood, provided sufficient foundation to confirm that conservation was an urgent need if the butterfly was to withstand continuing threats to its habitat, and that considerations of food plant availability and distribution were among the key considerations to help recovery of the butterfly and restore it across its former range.

These themes remained central to the expanding conservation endeavour and are discussed in later chapters, following further ecological perspective, but are noted here as the major guiding elements for conservation as practical perspective and measures were developed.