

**THE GENUS *PETALURA*: FIELD OBSERVATIONS,  
HABITS AND CONSERVATION STATUS  
(ANISOPTERA: PETALURIDAE)**

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The present distribution of the 4 spp. of *Petalura* in Australia is examined and compared with what we know of their former spread. The degree of diminution due to human intervention is assessed and their conservation status is prioritised as *P. ingentissima*, the safest; — *P. gigantea*, threatened; — *P. hesperia*, endangered; and *P. pulcherrima*, awaiting rediscovery and confirmation of specific status.

**INTRODUCTION**

The family: Petaluridae, Tillyard 1908, constitute an ancient family, traced back in the fossil record to mid-Jurassic times when they were a dominant component of the odonate fauna. These early members showed affinities with both the aeschnid and gomphid lines. Of the extant genera, *Petalura* has among the most spectacular dragonflies in the world, but is the least adequately treated in the literature. From FRASER (1933) we quote "Their distribution is discontinuous and suggests that they were at one time widely and universally distributed, but that with the progress of evolution wider and wider gaps occurred, until but a few remnants remain to tell us of a race of giants which is now all but extinct". Since this paper of Fraser only one publication deals exclusively with Petaluridae, a short but useful review by WINSTANLEY (1982); its content does not overlap with that of the present paper. For orientation there are 5 genera: *Petalura* with 4 species in Australia; *Uropetala* with 1 sp. (and a subsp.) in New Zealand; *Phenes* with 1 sp. (and a subsp.) in Chile; *Tachopteryx* with 1 sp. in the SE of N. America; and *Tanypteryx* with 2 sp., 1 in Japan and 1 in N. America from California to Canada (DAVIES & TOBIN, 1986). This distribution has been referred to as "scattered around the world", a view easily gained by using a map having Europe at its centre. By contrast, using a map with Polynesia at its centre, the distribution is clearly and strictly circum-

pacific and this fact is hardly acceptable as statistically insignificant, a topic to which we can return.

The status of the petalurid species at present is briefly as follows: the pessimistic view of Fraser is more true of *Petalura* than of the other genera and is the principal topic below. *Uropetala* is common, widely distributed and firmly established in New Zealand; *Phenes* has been little written about, but in most museum collections a drawer-full or more are commonly seen and specimens are easy to obtain from Chile; *Tanypteryx* species are common where found in Japan and abundant in many places in the NW of N. America: *Tachopteryx* is established over about 16 states of SW United States. We think that in this regard Fraser was looking far ahead.

The genus: the name *Petalura* was appropriately coined by LEACH (1815) who was adept at finding key root names which have become used as higher taxa (*Anax*, *Gomphus*, *Cordulegaster*, *Cordulia*, *Calopteryx*, *Lestes* and *Petalura*). The first species of the family-to-be was *Petalura gigantea* Leach, 1815 and was described nearly 2 centuries ago, the time of the battle of Waterloo which saw the nemesis of Napoleon's ambitions. Another century passed before 2 more species were found, *P. ingentissima* Tillyard, 1908 and *P. pulcherrima* Tillyard, 1913. The fourth species *P. hesperia* Watson was not discovered until as recently at 1957. *P. gigantea* has come to be regarded as 'not uncommon'; but that view holds only because there happen to be 'good colonies' near to both Sydney and Brisbane. Colonies are referred to rather than localities because their natural requirements dictate very localised areas where they are able to breed. Within the sparsely scattered colonies specimens are often numerous, but in spite of that, an uninformed visitor to Australia will not see a *Petalura* without informed guidance. It is no doubt the larvae which are responsible for confining the species to colonies due to the particular requirements of living in burrows (TILLYARD, 1911, 1917; WOLFE, 1953; ROWE, 1987).

Information about distribution and habits are so meagre that they can be quoted here in full from the only 2 published books that cover the odonate fauna of Australia. In "The Australian dragonflies", WATSON, THEISCHINGER & ABBEY, 1991, we find:

Species	Distribution	Habitats
<i>P. hesperia</i>	SWA	Boggy seepages
<i>P. gigantea</i>	SEN, NEN, SEQ	Boggy seepages, swamps
<i>P. ingentissima</i>	NEQ, CY	Stream margins in rainforest
<i>P. pulcherrima</i>	NEQ, CY	Unknown, rainforest

(SWA: SW Australia; — SEN, NEN: S and N New South Wales; — SEQ, NEQ: SE and NE Queensland; — CY: Cape York).

In "A handbook of the dragonflies of Australasia" FRASER, 1960, we find:

*P. hesperia*: local, but not uncommon where found, Oct.-Nov., habitats as for *P. gigantea*, in swamps bordering streams. W. Australia (3 localities given, 2 now defunct, one possibly just surviving).

*P. gigantea*: local, but not uncommon where found, Nov.-Jan. Breeds in swamps,

the nymph forming long burrows, from which it apparently emerges at night to feed. N.S.Wales. (3 localities given, 2 still extant, third unknown).

*P. ingentissima*: local, rare, probably has the same habits as *P. hesperia* but early stages unknown, N.Q. Jan.-Feb. (5 localities given, 1 still extant, possibly 2). In gorges at foot of mountains.

*P. pulcherrima*: local, rare, probably has the same habits as *P. gigantea*, but early stages unknown. (2 localities given but species rarely found since original description and these need critical comparison with paratypes).

With regard to larvae, TILLYARD (1911) described their lifestyle in good detail from studies of colonies of *P. gigantea* in the Blue Mountains in N.S.Wales, including the style of their tunnels which usually opened above ground. He thought that perhaps the larvae would take 2 years to attain maturity but had difficulty in finding young larvae due to the fragility of the lower tunnels that were in sand and collapsed too easily; he found only two sizes of larvae. Similar habits of the related genus *Uropetala* in New Zealand have been described in great detail by WOLFE (1953). In the dark soft mud in which they burrow it is possible to plunge one's hand up to about the elbow into a burrow and bring larvae to the surface for examination (pers. observ.). Wolfe concluded that the larvae had 15 instars and took 5 or 6 years to reach maturity. *P. ingentissima* in Queensland lives in a much more torrid climate and is likely to reach maturity much more quickly but one would not plunge a hand into a hole in the ground in Queensland (author's advice!).

For the most exciting dragonflies in the world to 'see in action' we beg to add a little to the data and give opinions as to their future prospects.

## OBSERVATIONS

Species are dealt with in the order of their discovery.

### *PETALURA GIGANTEA* LEACH, 1815

RANGE. — This is such a well known insect that it is worrying, on looking into the matter, to find how limited is its distribution. Leach's diagnosis of nearly 2 centuries ago does not give the source of his material, but now we know that the choice is small and we can 'figure it out'. He acknowledged his specimen(s) "... together with a vast number of curious neuropterous insects from New Holland" (New South Wales) as a gift from his friend the famous botanist Sir W.J. Hooker, later Director of the Royal Botanic Gardens at Kew, London. The botanists were in at the start of the Australian expeditions. Neither Leach nor Hooker ever went to Australia and the gift was no doubt part of a consignment, mainly plants from a friend of Hooker, who passed the insects on. Of the settlements in the first decade of the 19th century, Sydney was the most advanced; Governor Phillips moved the colony from Botany Bay in 1788 to Sydney Cove, for a better anchorage. In 1815

the population of Sydney was already 15,000. Paramatta, the penal colony was about 24 km inland and is now part of Sydney suburbs. The roadway between the 2 places would pass close to a well known *P. gigantea* colony and a specimen sighted along the road would have to attract attention, being so much larger than any species in Europe. The colony is now inside the metropolitan area, but a few specimens were seen there as little as 20 years ago where there is still a short length of stream beside some playgrounds and a few trees. They may still be there! It is a singular chance that a colony should be so situated because the Sydney area is one of the few with colonies on the mainland of New South Wales, most being on the offshore islands further north. The most northerly point of its range is about latitude 22°50'S in SE Queensland between Rockhampton and Mackay. This area has the features of a joint between a more northerly fauna and a different southerly one. A prime example is that to the S is found the ancient endemic synlestid relic *Episynlestes albicauda* and to the N the quite different species *E. cristata*. Near Mackay itself is a third, annectant, species *E. intermedia*, (at Eungella). In our case, to the S is *P. gigantea* and further N *P. ingentissima*. The former extends S as far as latitude 34°50' S, about 1300 km away. However, the species is confined to the coastal strip, at Byfield National Park, Deep Water National Park, Fraser Island, Beerwah (Glasshouse Mt. Area), the islands of Moreton Bay (Brisbane), Moreton Is., Russell Is., and N. Stradbroke Is., the latter may have more than one colony (REEVES, 1990); continuing across the border into New South Wales there may still be a remnant of the colony in north-central Sydney, and another S of the city in the Royal National Park (and the colony was not affected through the devastating forest fires there in 1994). Inland of Sydney to the NW, the Blue Mts extend for about 100 km and constitute, perhaps, the best area left for this species at the present time. There is an extended high ridge and from its north and south sides the water falls to well forested and swampy ground far below. Here there are probably many small colonies and wandering males are seen from time to time. The ridge is narrow and carries the main road and railway from Sydney through Penrith and to Lithgow, passing through about 8 small villages and including the Type locality for *Phyllopetalia (Austropetalia) patricia* at Leura. Unfortunately these villages have all expanded in recent times to quite large towns and use all the rainwater, sending it, we hope unpolluted, on down to the waterfalls. The Blue Mts are the only area where the waterfall rock dweller, *P. patricia* breeds and not a single specimen was seen last season (1996/7). Reasons why *P. gigantea* may survive this threat are mentioned below. On to the S there are colonies at the Gibraltar Range and the most southerly at Wingecarribee, S of Bowral. The coastal strip is quite narrow, varying from, say, 15 to 35 km wide (except for the Blue Mts area), and all populated and cultivated and huge areas have been drained to provide for all that. As desert occupies much the greater part of the continent, especially centrally, all of the expanding population, now 15 million, live along the coastal strips, particularly in the East, with which we are mainly concerned. Hints and rumours of colonies

“up in the hills inland” are heard but none has been pinpointed. There are hundreds (thousands?) of swamps up there but they have something the species does not like, or lack something they need. ARTHINGTON & WATSON (1982) studied the fauna of the eastern coastal strip and its sand-dunes and listed many of the colonies mentioned above, but no others.

**HABITS.** — All species of the family have burrow dwelling larvae and the present species does particularly well on the sandy offshore islands. We suspect that the ideal swamp is one with reeds and peaty-mud overlaying a sandy substratum. The water in peaty burrows would be poorly oxygenated but rich in food, but the burrows would give access to moving, adequately oxygenated, water seeping down below through the sand to the nearest water exit/stream. This feature would greatly limit the acceptable swamps and a little research in that direction would not be difficult. While this feature would confine the colonies to the kinds of places where we actually find them, there may be other needs in the composition of the soils and vegetation, e.g. it is a characteristic of both *P. gigantea* and *P. hesperia* breeding places that when hot weather comes, the knee-deep (or more) quagmire in which the burrows were made become brick-hard areas within a few days. It is a curious thing to find exuviae attached to debris lying on such rock-hard ground! Flight of the adults seems slow, but is in reality quite fast, deceptive due to their large size. In breeze it can be wildly erratic; but they are also inquisitive, the other species also. If you think they are watching you, you are suffering from illusions of grandeur, they are only interested in the usual things, sex and food, unless you are visibly aggressive. Mating can be very early in the day, even before the main day's flight has begun, a 'wheel' stage pairing may already be hanging on a pathside tree telling you that you have arrived at the right place. These can be really circular and unlike the parallel abdomens style pictured for *Uropetala* by WOLFE (1953). Males vanish as soon as the sun is obscured; females are rarely seen except as partners of mating pairs. Males do wander afar. For example at Stradbroke one flew around the sandy summit of the island (about 130 m high) (D.M. Reeves, pers. comm.). My communicant also describes oviposition at the base of clumps of reeds. Colonies tend to be in lightly wooded areas and never in rainforest. When resting on vertical supports, saplings of just a few cm thick are favoured and the abdomen is always set at an angle of 30-40° from the vertical. We believe that this allows them to see in both directions, i.e. both sides of the support, using the separation of the eyes and their independent focussing thus gaining the best view of mates or food. With nothing interesting in view, a specimen will move to an adjacent small tree and alight at the same angle but facing a different way.

**THREATS.** — This species has not been regarded as threatened. There is a strong colony S of Sydney and another at Stradbroke Is., a nice boat ride from Cleveland, the easternmost suburb of Brisbane. Both of these are in National Parks. These are where visiting entomologists are conducted to view these admirable beasts. But this is far from the true situation. All the mainland colonies already mentioned are

completely out of touch with one another and have no chance of genetic interchange nor repopulation if one colony suffered some catastrophe. As ARTHINGTON & WATSON (1982) already noted, the species is more safely installed on the sandy islands offshore. The coastal, largely sandy strip, with rainforested mountains rising sharply inland (The Great Dividing Range) is actually covered with vast areas of sugar cane, intersected by a web of narrow-gauge railways to transport the canes to the factories; also huge fields of pineapples to the horizon, and vast groves of bananas. To achieve this, great areas of land over a stretch of over 1000 km have been cleared of trees up to the rainforest edge, levelled, drained and planted, an area where we may judge that *P. gigantea* colonies were generously distributed. Commercial pressures will ensure that no land will remain uncultivated. Another worry is that the villages of the Blue Mountain Ridge, as already mentioned, are now towns and use all the water available that make the waterfalls. That was where *P. patricia* used to fly (TILLYARD, 1910). This is also National Park! Will *P. gigantea* survive this kind of change? Possibly, if we are right in thinking that they miss any polluted streams by living over the adjacent seepages of water draining into the streams, from rainfall that has not come from the tops of the high ridges but from the wide valleys that separate the ridges. Stradbroke Island is surely safe? It is also a National Park. But no, from the sand-spits of prehistoric times which are now the islands we speak of, the Pacific Ocean tides have separated light, pale yellow sand from heavy, black sand — wolfram, the ore of the valuable metal tungsten. This is important in particular alloys of steel in heavy industry (weaponry especially) and the mining operations are gradually spreading over the island, already affecting the watertables and threatening the *Petalura* colonies by reaching out further every year. If this is not stopped, the fate of *Petalura* there is, eventually, doomed. In addition this island is becoming a very popular tourist attraction. A photograph of a wayside lake taken in 1979 shows the lake as nature made it, having also 2 dune-lake endemic odonate species, *Orthetrum boumiera* Watson & Arthington and *Austrolestes minjerriba* Watson. Now it has a large car-park, barbeque facilities, toilets with precious water laid on, water sports etc. The water level has dropped by several feet, threatening the drainage features of a nearby *P. gigantea* colony; the only beneficiaries are well fed Goannas living off the debris around the garbage bins. In addition the 2 villages on the island have expanded to include a luxury hotel and areas of holiday homes. Similarly the Blue Mountains, only an hour's drive from Sydney are becoming developed for commuters' homes and weekend hideouts.

We quote from RYAN (1995), "As the development pushes outward, the remaining natural environments are coming under increasing pressure ... if present rates continue, all freehold bushland will be gone by the year 2012. Lowland forests, eucalypt forests and wetlands have also been drastically reduced ... In hinterland areas, the vegetation loss has been more severe." Needless to say, no petaluras are in the Brisbane area, yet this must have been the source from which the offshore

island colonies were originally established. Finally, the southernmost colony at Wingecarribee is now overlooked by waterworks and reservoir, altering already the conditions in the swamp. A day's work by a trench-digger-tractor could destroy the whole swamp for ever. Some practical steps will need to be taken to withhold the threats if the species is not to become endangered in the next few decades.

*PETALURA INGENTISSIMA* TILLYARD, 1907

RANGE. — Tillyard's paper in which this species was described, (together with a full redescription of *P. gigantea*), makes much interesting reading. On his first visit to Cairns in 1904-1905, a small village at the time, he had great hunting and showed his specimens to the local people. They were not impressed and he relates "I was told of the occurrence there at rare intervals, of a dragonfly of such enormous proportions that I scarcely credited the story. It was said to come swooping down 'like a bird' and local residents went so far as to declare that 'its bite would pretty well kill you'". On subsequently catching *Anax guttatus* at Atherton Tillyard thought that he had found the monster but the locals assured him that the one they spoke of was far bigger. A few days later he saw what they meant when 'the monster' flew along the banks of the Barron river, but he did not catch it. A few days later a local collector brought him a female 'from the bush' and subsequently a male also. FRASER (1933), 25 years later, was only able to write "Only a single pair of this remarkable insect are known, constituting the type and allotype in the Tillyard collection". By post-world-war II this largest of living dragonflies was known not uncommonly from along the lower rainforest edges from Cairns to Tully, Cardwell and Ingham, as correctly described by Fraser in 1960. More recently, with better roads and transport, specimens have been found up north around Mossman, Malloy, Julatta, Mt. Lewis area and on up to the Dunhunty river, lat. 13°50'S. (Reeves, pers. comm.). Sightings by non-odonatologists of very large dragonflies even closer to Cape York also exist, but there are other large species up there, such as *Anax gibbosulus* and *Austrophlebia costalis*, and actual specimens are needed for proper identification. Be that as it may, it is now clear that the species extends from probably about the Jardine river all the way down to not far short of Townsville, an extent of about 1000 km, living in the rainforests. These forests cover the seaward facing slopes of the Great Dividing Range and over the tops, being all well inside the tropics. The rainforest extends inland to more or lesser extent before changing into dry forest, perhaps 50 km or more but often not more than 20 km, except, e.g. where there has been widespread deforestation as at the Atherton Table-lands which is over the top but levelled, drained and cultivated, no doubt formerly great *P. ingentissima* country. Nevertheless 1000 km of forest, narrower or broader, is a vast area in which this species can breed in comparative safety as much of the forest is unexplored and impenetrable, specially the higher levels. They probably have continuity through most of this area, unlike the widely separated colonies of

*P. gigantea* on the flat ground below and outside the rainforest.

HABITS. — There are actually two strips of favoured ground for this species to breed: firstly the swampy edges of streams as they flatten out onto the coastal plain after falling down from the mountain tops through to the forest edge. Secondly, the mountain-tops, very difficult of access until recent times and still with only a few easy access points, where there are boggy edges to countless small channels, draining into small streams and gradually coalescing to form larger streams, small rivers and finally tumbling down through precipitous rocky waterfalls, or one great waterfall, over the hundreds of metres to ‘ground level’. The steep falls themselves are not *Petalura* places but homes of many other ancient relic species, too specialised to be ousted from their particular niches. The *Petalura* uses all the ground above the beginning of steep, stony falls. The mountains along this 1000 km long range provide good safety for their insect fauna. Adequate flat gullies and valleys among the mountains also, of course, provide breeding grounds. Interaction throughout the forests seems likely from the frequent encounters with wandering males, searching for soft juicy ground with drainage, where the females will be busy. Males and females are rarely seen together and males only rarely along the creeks where the oviposition sites are located; these are often very deep sided and require machete and secateurs to climb down, but breeding points are indicated by exuviae on creek-side tree trunks (unless they go for very long walks!). Females will lay in very small patches of mud and the species is not a colony dweller, rather they search the forests for each other and are well equipped to do so. Both sexes, but most often males, frequently perch and view their surroundings ‘at leisure’ and at the usual angle of 30–40° when on vertical perches, scanning both sides of the slim perches usually chosen. Males, in addition often choose the top of a prominent object; a human denizen of a forest village said to me, “yes, they sit on top of my clothes-line post and watch me gardening”. If frightened they disappear to a speck in the sky in a few seconds, but normally they are almost friendly and inquisitive, e.g. a male settled on my companion’s hat in a forest clearing and was safely netted by a “William Tell” act without damage to either party. A male flew alongside our open car window for about 200 m as though ‘just for fun’, at about 75 kph, in the narrow space between the car and a high bank; I could almost have caught it by just putting my hand out, if there had not been a precipice on the other side to think about! Females are also great at minding their own business: if you choose to follow one (and if the terrain permits) you get the impression that she is moving away from you to a new perch, each time you approach, but is not, in fact, at all interested in your antics and is quite likely to turn round and fly directly to you (or into your net if you hold it up) because she is actually just spying out an oviposition site. Oviposition has been described by several observers. Where deep soft mud is chosen the abdomen is probed deeply to about all its length, most of 10 cm (S. Butler, pers. comm.). More often less deep mud is chosen, but even then eggs are placed well below ground surface. How the newly hatched larvae deal with this

situation would be interesting to study. The arrival of a male at your clearing, and his careful and steady flight round its perimeter is an awesome sight: his majestic attitude makes you feel an intruder. The activities and antics require some kind of opening or clearing in the forest for observation, and these are usually man-made, such as some old mining activity partly regrown. Specimens most frequently appear from the top, dry, end of incipient streams, having flown up from watery levels further down, and seek a perch. A stake in the ground will suffice in a small clearing, a telegraph post if there is one, but normally all these activities must be taking place up on the canopy, away from our prying eyes. There are interesting new observations about feeding. Specimens perch on (observe from) high branches of forest trees and pounce down upon large insects passing by, such as a mating pair of some libellulid, and a Swallowtail of the genus *Graphium* (D. Tagg, pers. comm.). These were taken on down to the ground to be consumed ('to be ground up!'). *Papilio ulysses* has previously been seen captured as prey (entry in the Red Data Book notwithstanding).

**THREATS.** — Breeding places at the bottom edges of the forests already referred to, are greatly diminished because from, say, Daintree to Townsville, the ground is covered with sugar cane, pineapples and bananas as already mentioned as the main enemy of *P. gigantea*. But these plantations often run up actually to the forest edge and to where the creeks emerge from their precipitous course down the mountainsides. These water sources have been tidied up as irrigation channels and the muddy edges destroyed. In addition, these water sources often make ideal and spectacular campsites, with barbeque facilities, toilet facilities and muddy areas 'cleaned up'; these are well placed, having easy and convenient access from the North-South Bruce Highway. Urban expansion takes its toll. As recently as 20 years ago, Cairns was a village/small town where ibises were the friendly local scavengers, busy beside you in the grassy roadside ditches, is now a city centre. Buildings extend up the lower slopes of the hills and polluted water comes down the creeks from the former beauty spot, Kuranda on the mountain top, now a tourist centre. The creeks around Kuranda are mostly dry, the water required for the urban sprawl, but some breeding still persists there (D. Tagg, pers. comm.). Farming expansion is not only on the coastal plain. An excellent *P. ingentissima* area existed between Kuranda and Mareeba, further inland, but this was completely ruined only a few years ago by the local farmer releasing his cows into the creek. Further north it is still possible to buy 'retirement homes' in the rainforest, with all services provided (Daintree). Most surprisingly some logging is still in progress due to the persisting validity of old customs, claims and permits, in spite of the whole area being 'World Heritage' and much of it National Park. So reduction of population of this species has certainly occurred. But, unlike that same outcome for the other species, this one with about 1000 km of largely impenetrable rainforest at its disposal, even if of variable width, is certainly a safe haven and large areas have population continuity between the many small and some larger breeding ar-

eas. The total population is judged to be much greater than the other species. Its inaccessibility is greatly in its favour. Even some politicians believe that we should preserve some rainforests.

*PETALURA PULCHERRIMA* TILLYARD, 1913

This enigmatic species is very poorly known and recently a new view has been proposed that it is really a 'form' of the previous species, but with a more yellow colouring. The view is based on photographs and until specimens have been captured and carefully compared with Tillyard's paratypes, we will not be sure where we stand. In the meantime we will assume in what follows that until otherwise persuaded, it is a good species as described and named by Tillyard.

RANGE. — A series of 6 males was captured by Tillyard in 1908 at Cooktown; all are identical, are in excellent condition and well coloured and preserved in safety; one of these is the holotype. This paper is not at all concerned with descriptive nor taxonomic aspects of the genus, but it is necessary to add that the female allotype is not from Cooktown but from Kuranda, as designated by Dodds. However, a very critical article (which we have mislaid) was published recently saying that Dodds' localities cannot be relied upon because he labelled most material 'Kuranda' where he lived, not wanting to reveal where his rarities for sale had originated. It is therefore safest to take the view that we do not know the true origin of this specimen. It is relevant that *P. ingentissima* still breeds in the Kuranda area, though many creeks are dry there now due to the requirements of urbanisation. Apart from a specimen supposedly *P. ingentissima* but with markings intermediate with those of *P. pulcherrima* and in need of further study, there are at least another 6 specimens labelled *P. pulcherrima* in museums in Australia (D.M. Reeves, pers. comm.), all from different localities and also all in need of proper side-by-side comparison with a Cooktown paratype. It would not be new to Australian odonatology to be dependent on the number or size of coloured spots to allot specific names and a good series of specimens can be needed to make the decision statistically (WATSON, 1991). No such long series of specimens exist for any of the petaluras. Cooktown has not been easily accessible for entomologists, but the species has not been seen there since 1908. At the turn of the century it was a large town, being the trade centre for the Palmer River gold-rush of the 1880s. It is now smaller, but uses more water for its modern lifestyle and its creeks are dry. To make things worse, as at 1989, there had been a 7-year drought and the forests were looking very drab. Since then a few cyclones have improved that. Only one likely looking place has been found there in which one could visualise *P. pulcherrima* breeding, an excellent, winding, sunken, sand-gravelly filled stream bed, but totally dry. The owner of a nearby cottage said, nevertheless, that after the wet, he has known water to run there 'more than once' (over the years!). We judge that it runs, perhaps much more often, underground, which might be adequate for what we think we need. Over

recent years we have had several sightings of a large petalurid between lat. 15-17°S that looks quite different from *P. ingentissima* (with which we are adequately familiar) and when flying by at about head-height gives the impression of having yellow rings down the abdomen, as opposed to yellow lines. One perched at our base, but while I was wading up-river. We believe this is real *P. pulcherrima*, but until a specimen is caught no claim beyond this is being made. Sightings have all been near a boulder filled river, but boggy river banks are few. While feelings have been expressed that this species is more northerly than its larger brother, from Cooktown up further towards Cape York, 4 of the 6 “newly found” museum *pulcherrima* specimens mentioned above come from S of Cooktown, one has no data, and one is not known to me (is at A.N.I.C. Canberra, J.A.L. Watson, pers. comm.). However, one *P. pulcherrima* is reported from the Iron Range, only 250 km S of the northernmost tip of Cape York. Dates of 4 of the other 6 are: 1951, 1964, 1986 and 1992. All that have adequate data came from between approx. lat. 16-19°S, but no two come from the same place.

**HABITS.** — One can say almost nothing useful about habits beyond what was in TILLYARD’s (1913) paper. Our possible sightings are in rainforested areas and near riversides.

**THREATS.** — Nothing useful can be said, except that the species is local and rare. It would help if the 5 specimens with exact co-ordinates were properly and critically compared with the paratypes that are readily available and if they are approved *P. pulcherrima*, then a number of places would be worth searching, and we await enlightenment from some lucky hunter one day.

*PETALURA HESPERIA* WATSON, 1958

**RANGE.** — This species is confined to SW Australia. It is not generally realised outside Australia that this is a very small corner, almost an oasis and smaller than the U.K., bounded by the Indian and Southern Oceans to the W and S, and by thousands of kilometers of desert to the N and E. So isolated is it that half of its odonate fauna is endemic (18 spp.) and there are also several endemic genera!. A very large dragonfly had flown through the front door of a house in Lesmurdie, a village about 15 km SE of Perth, and frightened the lady inside, who did, however, have the good sense to catch it. It was later apprehended by the late Dr Tony Watson, then recently returned to Perth with his PhD from Cambridge who named and described the species. He subsequently became a notable odonatologist and made great contributions to Australian dragonfly studies. Was it the *Petalura* that led him in that direction? He subsequently named about 45 new species; Tillyard, with an earlier, clearer field, described 85 new species. The Lesmurdie site is now an area of housing estates. A well-known colony conveniently sited for study was found by Watson at Bull Creek, but this is now Bull Creek housing estate and the swamp, crossed by a highway, is reduced to a very small area with a patch of mud on each

side of the road with a short remnant of a stream. The whole site is well inside the urban area of Perth. In spite of this we were astonished, in 1980, to see 3 specimens over a checking period of about 6 weeks. Obviously this was no longer a 'colony' of any account in assessing the status of the species, however, one can but admire the tenacity of the species, surviving in such an unsuitable habitat. Searches at all other recorded sites in that year showed that the *Petalura* was not at any of the earlier (pre-1980) places where sightings had been made. This seemed a very serious matter, because the range of suitable breeding grounds, based on old sightings, geology, drainage, vegetation etc. suggested that the whole of the possible habitats lay within limits of only a fraction of the thousands of km we have talked about for two of the other species. Indeed the distance between the most northerly and southerly sightings we made in 1980 was about 110 km and the width of the strip probably between 10 and 20 km. It is sad to report now, that this has not changed. TILLYARD (1908) described his exploration of SW Australia and found all of the (then) new endemic species and the several endemic genera, but he did not see the *Petalura*. This is surprising and worrying as it suggests even before the Darling Range dams were built across nearly all the rivers and before extensive deforestation, the species was not an easy one to find. The colony we eventually found we were led to by nearly colliding with a heavy flying object as we both passed between the same pair of trees. We followed him to his lair! We later discovered that this colony was already known. It was a hive of activity with scores of males rushing around. In spite of that it was late afternoon before one had entered a net and a new and curious technique had to be developed to cope with that. What turned out to be a knee-deep quagmire the following year was, on this first visit, an area of rock-hard baked mud, albeit with exuviae on dried-up reed clumps etc. A group of local (SWA) entomologists/naturalists have taken up the challenge and are looking into the status of *P. hesperia* right there, on the spot (BARRETT & WILLIAMS, 1998). Their sightings do not extend outside those mentioned above, but important is their finding of another 'good' colony, i.e. one where 20 or more specimens may be seen on a suitable day. Two colonies are more than twice as good as one. But the total number of specimens thus far is much smaller than provides for a safe future. The group, answering to an organisation called CALM (Conservation and Land Management) believe that their sightings of single specimens here and there indicate more colonies, because the species is said to be 'sedentary', and these colonies will be in gullies of streams running into the reservoirs from above. We hope they are right: the terrain up there is hard to search. But we do not think they are sedentary. At a stream well known to Tillyard, now running between fields (but probably still wooded in his time) and where we have frequently visited, wandering males have 3 times been seen crossing the fields, stopping briefly on each fence and moving on. There is no colony in that area. The first colony is on Forestry Commission land, the 'CALM' colony is on land described as 'secure'. BARRETT & WILLIAMS (1998) list 19 places where *P. hesperia* has been seen since it was first

discovered, notwithstanding that only two 'real' colonies are known at the present time. Some of the sightings are certainly places where good colonies once existed but most are of wandering individuals. No sightings have been made N of the Swan river which runs through Perth, in spite of a very large drainage area there providing for the Mundaring dam, built almost 100 years ago, which sends water through a 550 km pipeline to the gold-mines at Kalgoorlie, out in the desert. Some ideal looking stream beds can be seen in the Darlington area, similarly sited to the former excellent Bull Creek colony, but permanently dry, as shown by the vegetation. These ran into the Helena river, a substantial tributary of the Swan river but itself rarely running from overflow of the Mundaring dam. Streams running into the Mundaring reservoir 'should' be good sites but have been explored with no good results. The population of Perth was quite small 100 years ago, it was about 500,000 when *P. hesperia* was first found (1957) but has since tripled due to its popularity for immigrants from other parts of Australia (too hot, too dry, or too wet). Will the city continue to feed the insatiable desert and provide for its precious dragonfly?

**HABITS.** — The species breeds alongside sunken streams which are slow-running enough to support deep, muddy seepages of good width. These flow down shallow valleys through heavy Jarrah forests that drain the westward slopes of the Ranges. This mud, up to a metre deep, quickly takes on a brick-like hardness when the 'Wet' stops. This is very much like what happens in *Hemiphlebia* colonies after emergence is complete; the larvae know exactly when to climb out and not end up inside a brick (DAVIES, 1985). Exuviae are found on sides of tree-ferns, 'Black-boy' trees, clumps of dried reeds and sometimes the larvae will climb up saplings of a few cm diameter and settle 2 or 3 m up to emerge. The situation suggests oviposition much like that described for *P. ingentissima*. Unperturbed by a recent big burn, adult males rested at the customary angle of 30–40° on burnt saplings and viewed their black world (with equanimity?). This patch has regrown into an impenetrable jungle in the last 15 years and the colony has moved downstream to a more reedy area. At an exposed stream between fields (and also known to Tillyard), we watched a pair of *P. hesperia*, about 30 km from the nearest known colony, but on an ovipositing expedition. They approached the only 'gungy' patch which was only a few square metres in extent and here the female stopped 3 or 4 times in as many minutes while the male was 'hanging around' low, among the line of trees above, in attendance. They flew off together downstream at high speed. We are not aware of such paternal interest during oviposition in the records for this genus. In a colony females are rarely seen; on a hot day in mid-season where many males were around, only 4 females were seen in the day but all as partners of mating pairs. The colony was very lively up to the third week of January, but a week later nothing was seen and it appeared that it was all over for the season.

**THREATS.** — The local group, (BARRETT & WILLIAMS, 1998) believe there is no reason to suppose, nor has anyone suggested, that the species is in general decline. On this point we have to disagree and we believe that the species is in rapid

and dangerous decline. In actual fact all we know of are 2 flourishing colonies. If one was lost by some disaster, there would be only one and the species would have to seek extreme protection, not just an entry in the Red Data Book. This is, after all, a precious relic of the ancient past and who are we humans to show such greed that space cannot be found for an animal with such modest needs? What kind of disasters could occur? They happen every day to some animal and plant species. Fruit farms are surely the *Petalura*'s worst enemy. The whole Perth area and on to the south are covered with them; the seepages along the upper scarp of the Darling Range, where the drainage is just beginning to form into a stream, are possibly where large populations once lived. These places are ideal for, and now covered with orchards. In the colony I have in mind, there are two orchards astride the *Petalura* stream, each with a dam and lake, from which water is pumped up again for recirculation in dry periods. Some water comes through, but in a bad season for fruit, one day it might not. In any case, each time the water is recycled it picks up the insecticides and other pesticide 'dressings' that the trees receive each season. The burrows of the petalurids are not in the mainstream of water, but are more likely using seepage water from the sides of the forest valley, draining into the main stream. But, in the stream itself are three SWA endemic genera of odonates (*Lathrocordulia*, *Hesperocordulia* and *Armagomphus*). At this, the best colony known now, breeding has moved downstream for some distance in the last 20 years. Its former spread has now very thick undergrowth through which no dragonflies can fly. Is this due to too much light penetrating the canopy due to 'die-back' infecting the jarrah trees, a well known problem in the general area? Be that as it may, downstream of this reach but above the present breeding area is an artificial lake made for children to swim in. Some years this cannot be used due to infective protozoa and has to be treated with pesticides to be 'safe' for swimming. It remains to be seen if this will damage the other aquatic fauna.

We believe that 2 colonies are quite inadequate for complacency and can only classify the species as endangered. The importance of searching for new colonies can hardly be overestimated and we eagerly await news in that area. It is hard to estimate the number of specimens that compose a good colony but the SWA population as a whole is, by any standards, very meagre. It would be nice to talk about expansion, but at the moment maintenance of what exists requires close attention.

## DISCUSSION

Discussion items have mostly been incorporated in the text, following the points to which they related. There is a little still to be said. Australia is generously blessed with great natural resources, but "...freshwater is Australia's most precious resource and development progressively alienates it: dams and bores tap water, wetlands are drained, waterways are polluted ..." (WATSON, 1981).

For *P. hesperia* we cannot agree with attaching significance to single sightings,

especially at former important sites now overtaken by urban usage. These specimens do not contribute significantly to the total population of the species. If we were to assess the numbers formerly contributed by just a few of the old well-known sites then with 2 good sites remaining, the total population will have more than halved since the 1950s. We only hope that the 'CALM' group are right in thinking that more remote sightings further south will lead them to 'new' sites. In retrospect, our best area at the present time may well have extended 1 or 2 km upstream are now that distance downstream, because of the encroachment of the fruit farms by slowly clearing trees and adding ground to the orchards and dams astride the stream.

It should be added that along the top of the main ridge, extensive mining of alumina is developing and it is not known what plans they have and whether this is to be a new threat in the future.

Due to reservoirs built now on nearly all the streams and rivers draining the Darling Ranges W towards the sea, the total water now arriving at the coastal plain, which is between 10 and 30 km wide, with its industrial sprawl and numerous 'water-works' (boreholes), is so reduced that the superb parallel N to S rows of fresh-water lagoons are dried up. They are now shrub-filled depressions. The important research on speciation in the *Argiolestes pusillus* complex, started by TILLYARD (1908) and developed by WATSON (1977), cannot be continued as they were dependent on the ssp. of these lagoons. All those key localities are permanently dry (we checked them last year) and we have to presume that *Argiolestes parvulus* Watson is extinct.

We believe that the stronghold of *P. gigantea* was the sandy coastal strip from about Nowra in N.S. Wales to Yeppoon in SE Queensland. The particular requirements for the species are also just the requirements for sugar-cane, bananas and pineapples, so there are now just a small number of remnant colonies left which are out of touch with one another. There are about 6 colonies or breeding areas scattered along that 1500 km of coastline now. This species most clearly shows the way of finding oxygen from fresh moving water below and food from 'gungy' mud with vegetation above. This is probably the same for the other species which use burrows. In the meantime the other relics of the past go to great lengths to do the reverse and hang, perilously in precipitous waterfalls for maximum oxygen supply. The moderns (libellulids etc.) we have to suppose have improved tricks of physiology to tolerate low oxygen levels in static deep pools.

The probable *P. pulcherrima* site at Cooktown is of a sandy-gravelly nature with 'additives' and perhaps they burrow rather deep to find water more regularly than it appears above ground. Might this lead to a somewhat smaller and lighter coloured form of *P. ingentissima*? Is this idea sacrilege? It should not be necessary to ask the question. In addition to Tillyard's paratypes available in Australia, there are to our knowledge, at least another 8 specimens labelled "*pulcherrima*" all caught at different times and in different places and mostly in Australian museums (D.M.

Reeves, pers. comm.). Three, recently revealed ('unearthed'), were caught in 1951, 1964, 1992. A fourth is undated. All these should be checked, side by side with a paratype and if identification is correctly determined will indicate places to look for a breeding place. It has been hinted in the past that *P. pulcherrima* has a more northerly range than its larger co-gener, but in view of the Iron Range record for *P. pulcherima* it seems that Cooktown is about the centre of its range. And recall that *P. ingentissima* lives up to 500 km at least N of Cooktown.

In a constructive insect conservation report, KEY (1978) expands mainly on habitats for dragonflies but does not include *Petalura* habitats. For the latter, the Dept of Forestry SWA should be alerted to the mining, tree-felling and orchard-spread down the Darling Ranges as it begins to look as though they are caring for, without knowing it, perhaps about the rarest dragonfly species in the world.

Like all groups, organisations, large and small who study, assess and reach sensible decisions and finally make recommendations in the area of conservation, the recipients of their reports rarely have money to put any plan into action. The world of conservation is toothless. If anything reaches political level, commercial considerations will sway any political decision. If any member of these organisations were bright enough to be able to define an insect, they would not know why anyone should want to conserve them rather than tread on them (or swat them!). Be that as it may, we will still classify our subjects for the record:

STATUS. — *P. ingentissima*, because of the extent of its forests and safety from most kinds of substantial interference, and because they have genetic interchange through their range or through substantial parts of it, must have the largest population and be the safest of the genus.

*P. gigantea*, because of having so few colonies or breeding areas and having lost genetic interchange down the range of their mainland and also their island colonies and are, in some of their best colonies threatened by mining and water depletion, give serious cause for worry, and are perhaps threatened.

*P. hesperia*, because of having only 2 substantial and surely known colonies, a loss of many colonies due to urban spread and urban water requirements, difficulty in assessing the significance of wanderers, the most important activity now is the search for possible additional colonies. If these are not found, the species is endangered. There are threats from spread of fruit-farming and perhaps mining. If new colonies are found, especially in streams feeding reservoirs for water supply to residential areas, then the situation would be greatly strengthened.

*P. pulcherrima*, because we do not know for sure where they breed and probably only about 14 specimens have ever been found, the status of this species cannot be assessed. At least several localities and co-ordinates are known for the specimens apprehended already, so new and helpful information should be forthcoming. We can only stay with FRASER's (1960) pronouncement that the species is local and rare.

On a more cheerful note, it does seem that the petaluras have exceptional persist-

ence for survival, long term, after a breeding area has been seemingly, fatally spoiled by human intervention (for his own 'requirements'). *P. gigantea* (as already mentioned) survived in an old colony now in Metropolitan Sydney until recent times and may not be extinct there. *P. ingentissima* survives in a very small damp patch of a few sq. metres in the corner of a large, dried, cleaned campsite alongside the Bruce Highway; three specimens were seen there recently. Of *P. hesperia* a few (2 or 3) have been seen most years over the last 2 decades on one or other side of the Leach Highway that crosses Bull Creek in South Perth. They fly between the Swan river and the Bull Creek housing estate. Perhaps *P. pulcherrima* will turn up again at Cooktown if someone is there at the right time, in the right year, in the right weather.

As mentioned in the Introduction, all 9 species of the Petaluridae are located approximately on the Pacific Ocean 'rim'. However, the distribution is much more precisely determined than that and tells us something about the origin of the ocean itself. To account for geological features of the rim, NUR & BEN-AVRAHAM (1977) postulated an old continent, 'Pacifica', located over northern Australasia, which broke up in about Permian times into 7 pieces identified geologically and geomagnetically as follows, two over Australasia; one over Japan; one over Chile-Peru; one over NW of N America and two now under the arctic ice. It is beyond any reasonable conception of statistics that chance could allow for all the Pacifica 'patches' to be the location for at least one of the 9 species of extant Petaluridae (except those under arctic ice). Not only that, but that only one of the 9 extant species is elsewhere than on one of those patches (*Tachopteryx* in SE of N America). Unfortunately, we believe that no source of energy has been invoked to split up and distribute the pieces of a continent in the way suggested. So there must be some other, perhaps simpler (?) explanation. The view that the earth is expanding (WARREN-CAREY, 1975) is gaining increasing attention as a way of explaining seemingly impossible happenings in the distant past. At the time we speak of, ca 225 million years ago, there was probably a much diminished Pacific Ocean, if one at all, as the whole shape of the continents was quite different. At the time, e.g. the North Pole was situated, if entered on a today's map, about central Pacific and about 10-20°N. We are comfortable with the idea that the Atlantic Ocean is relatively 'new' and materials at its edges were, at one time, in contact. In the same way, but with 2.5 times as long to complete, a much more vague idea of the world map is all one can expect, but what was in the centre of the area is now at the edges and inside is the Pacific Ocean. Maps for the world as it was 200 million years ago and how it has changed are presented in detail by OWEN (1983). Recall that the Odonata go back about 350 million years, and recognisable ancestors of the Petaluridae 250 million years back in the fossil record; one would like to add "and still going strong" but to keep them at all we will have to help them because we are making their lifestyle obsolescent.

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