

THE ODONATE FAUNA OF NEW CALEDONIA, INCLUDING THE DESCRIPTIONS OF A NEW SPECIES AND A NEW SUBSPECIES

D.A.L. DAVIES

23 Cedar Court, Cambridge CB2 2QJ, United Kingdom

Received September 25, 2001 / Reviewed and Accepted February 9, 2002

An updated list is provided of the 55 spp. known to occur in New Caledonia, with some behavioural and distribution data, and with information on possible origin of the spp. which found and colonized the island. The new taxa described are: *Adversaeschna brevistyla caledonica* ssp. n. (holotype ♂: New Caledonia, Yaté-Goro Rd, 22-II-1983), and *Synthemis pamelae* sp. n. (holotype ♂: New Caledonia, Mt Koghis, 9-V-1983). Also described are the previously unknown ♂ *Metaphya elongata* Campion and the previously unknown ♀ *Synthemis serendipita* Winstanley. All type specimens are deposited at CUMZ, Cambridge, UK.

INTRODUCTION

The island of New Caledonia is a Department of France. It was discovered by Capt James Cook in 1774. He used the old Roman name 'Caledonia' i.e. northern Britain, still commonly in use as the name for Scotland. This was also appropriate to his previous naming of the adjacent 'New Hebrides'. He found the islanders very co-operative "No people could behave with more civility than they did". But their language was new and not related to those of more central and eastern islands, so not understood by Cook and his crew who were in a hurry to get to New Zealand and only sailed down the East coast, which is where the mountains 'fall' treacherously into the sea. The low lying West coast would have attracted his attention more if he had seen it.

The fauna and flora show clear signs of some catastrophic event in about Oligocene times that made the island uninhabitable and a recolonisation of a very interesting kind took place. Geologists have shrunk from postulating that it sunk below the Pacific Ocean (though this has been hinted at by naturalists); the problem is addressed by LILLEY & BROTHERS (1968) and BROTHERS & LILLEY (1988). Now there are mountains up to 1600 m. The island is about 400 km long and 40 km wide. It is

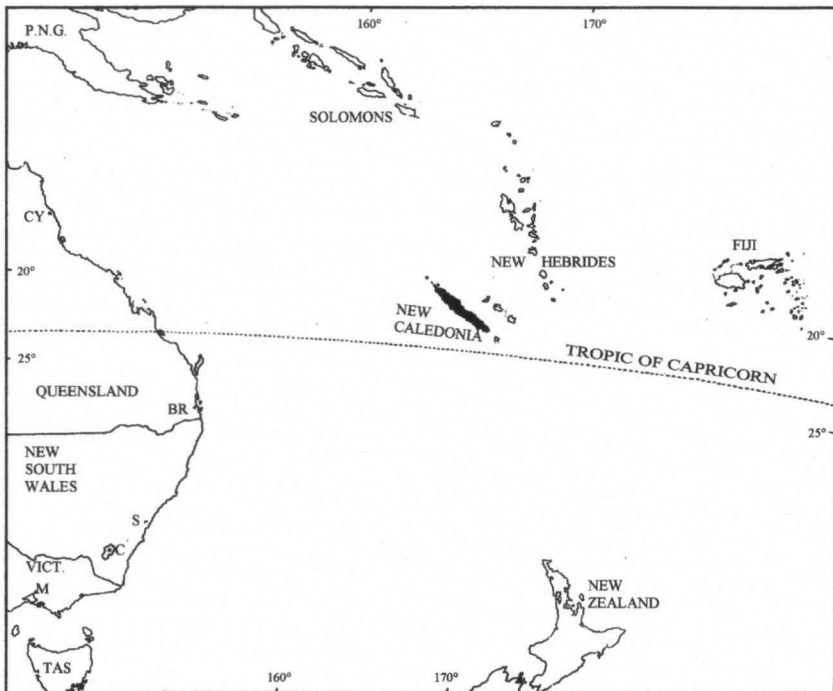


Fig. 1. New Caledonia, map showing position of the island in relation to the nearest land-masses.

unlikely to have suffered from gross volcanic disturbances, not being on the line of volcanos running down the East of Asia, through the New Hebrides and down to New Zealand. (PETERS, 1989). Only harmonics shake New Caledonia (N.C.) gently sometimes.

The problem of a repopulation from afar remains unsettled, but some hints are clear. The Australian East coast, the Solomon Is and Fiji are ca 1200 km distant, New Zealand is about 1600 km away and Papua New Guinea (PNG) ca 1800 km to the NW (see Fig. 1); currents and prevailing weather are also relevant.

Eighteen of the 55+ odonate species in N.C. are endemic, 2 of these are, however, also found in the Loyalty Islands which, with the New Hebrides, have some species related to northern and easterly sources. Many modern adaptable and long ranging species are clearly relative newcomers. The endemic species are mostly in the Isostictidae, Megapodagrionidae and Sythemistidae.

In the present paper, an updated review is provided of the species known to occur in New Caledonia, along with some behavioural and distribution data, and with information on their possible biogeographic origin. *Adversaeschna brevistyla caledonica* ssp. n. and *Synthemis pamelae* sp. n., as well as the hitherto unknown sexes of *Metaphya elongata* Campion (♂) and *S. serendipita* Winstanley (♀) are described and illustrated.

DESCRIPTIONS

ADVERSAESCHNA BREVISTYLA CALEDONICA SSP. NOV.

Figure 2c

Material. — **Holotype** ♂: New Caledonia, Yaté to Goro Road in far SW of N.C., 22-II-1983, Pamela Tobin leg. — **Paratypes**, 6 ♂ from type locality. — **Allotype** ♀: same locality and date, D.A.L. Davies leg, one specimen only. All deposited at CUMZ.

The status of the old '*Aeshna brevistyla* Rambur' has been influenced by the discovery of *Oreaeschna dominatrix* in N.C. in 1983-84 (see VICK & DAVIES, 1990). Discussion over this surprise and closer examination of *A. brevistyla* from Australia and from N.C. revealed that there were unexpected similarities between the new *Oreaeschna* and the N.C. form of the other species, different genera notwithstanding. This put an end to speculation that the Australian *Aeshna* came from S. America before the Antarctic ice cap was in place (recall that the Neopetaliidae are in southern Australia and in S. America only). It hinted at a look in the opposite direction. *Oreaeschna* has only one other species, the genotype, *O. dictatrix* Lieftinck, endemic in PNG (LIEFTINCK., 1937), but that is 2000 km of ocean away. WATSON (1992) probed deeply into this problem and chose to support *A. brevistyla* as a possible fore-runner of *Oreaeschna*, (note, not the reverse) and put the Australian species into a new genus, *Adversaeschna*, a name previously used by TILLYARD

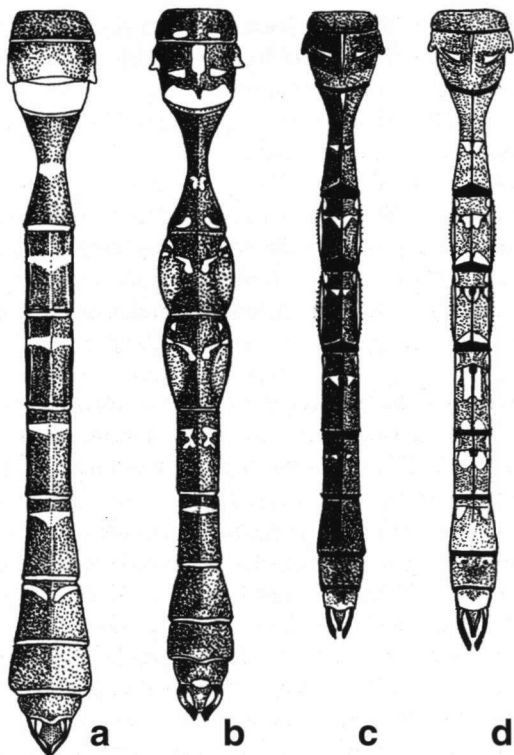


Fig. 2. Abdominal profiles relating *Oreaeschna* and *Adversaeschna*: (a) *O. dictatrix* Lieftinck, from New Guinea, (redrawn from holotype figure in LIEFTINCK, 1937); — (b) *O. dominatrix* Vick & Davies, from New Caledonia, redrawn from holotype in VICK & DAVIES, 1990; — (c) *A. brevistyla caledonica* ssp. n., specimen from New Caledonia; — (d) *A. brevistyla* Watson, from Australia, kindly loaned by Ray Andress Esq.

(1916). It is not so difficult a journey from northern Australia to PNG and this close (geological time) connection might indeed provide a development of *Adversaeschna* to *Oreaeschna* (evolutionary / adaptive time). *Adversaeschna* is not related to the Australian Aeshnini, which belong to the higher taxon, Brachytroninae (which includes *Austroaeschna*) and having quite different venational features, so where did *A. brevistyla* come from? PNG is not a haven for Aeshnidae; no Aeshnini (a worldwide taxon with about 120 species) got there, they never crossed the 'Wallace Line'. Only about 10 Anactini and about 6 Gynacanthagini have been reported from PNG. Perhaps over many millions of years it might have come from continental southeastern Asia to western Australia and spread continent-wide. The epicentre of the species encompasses a range of territory: hot deserts to varied tropical and temperate forests and must maintain a gene-pool catering for very wide coverage.

The point is that *A. brevistyla* from N.C. are easily distinguishable from Australian specimens. They are much darker and less marked with spots, the lateral thoracic stripes are narrower and bluish instead of bright yellow, and to justify a subspecific name, they have shorter superior anal appendages (N.C., less than 3 mm; Australian, more than 3 mm: both $n = 8$); *oreaeschnas* are 2 mm or less. For these reasons a new subspecies name is coined for the N.C. population, *Adversaeschna brevistyla caledonica*. All of these characters are "in the direction" of those in *Oreaeschna* and also include a hint of an lateral expansion of the abdomen over segm. 3-5 and 7-8, an outstanding and unique part of the structure of *Oreaeschna* and seen very clearly in the figure in VICK & DAVIES (1990), the original description and in Figure 7 below. TILLYARD (1916) described 2 forms of *A. brevistyla*, 'lineata', with an antehumeral green stripe, and 'oblita' having no such stripe. This is not a good character because there are intermediate forms. However, among the specimens available for examination we have, Australian, 7 lineata and 2 oblita; in NC specimens were 6 lineata and 4 oblita. *Oreaeschna* has very distinct, broad clear antehumeral stripes though rather variable in width. One might postulate that 'old' *A. brevistyla* found its way to both PNG and N.C. where the gene pools adapted to tropical forest life with a much smaller gene pool, with superficially similar new forms in both places. The nominate species is common over all of Australia and likewise the N.C. subspecies is common over all of New Caledonia.

METAPHYA ELONGATA CAMPION

Figure 3

Material. – **Allotype** ♂: New Caledonia, Konkoinhi stream crossing the Yaté to Goro road, at extreme southwesterly point of N.C., close to sealevel, 30-II-1983, D.A.L. Davies leg. – Other material: 6 ♂, 9 ♀, same place and date. All deposited at CUMZ.

This species was named (CAMPION, 1921) from a female found by Mr Paul Montague at Baie Ngo in SW N.C. 10-II-1914. Campion studied specimens of the other two *Metaphya* species before deciding on putting that female into this genus

(with *M. micans* Laidlaw from Borneo and *M. tillyardi* Ris from PNG). 'Elongata' refers to that female, now deposited as holotype at BMNH. Now we will see that the epithet does not apply to the male. LIEFTINCK (1975) plants a degree of doubt on this placement and thought that the male should be examined first. The species was not uncommon in the type locality especially at a deserted native village site not yet heavily reforested.

H e a d. — Labium brown, face shiny black except for pale clypeus. Vertex pale, small, antennae black. **P r o t h o r a x.** — Mainly yellow, pair of forward facing yellow hooks on first segment. Dorsal profile high on lobes 1 and 3. **T h o r a x.** — All shiny dark green and bronze with no markings. Legs black with rather irregular, fine hair-like spines. Wings, entirely hyaline (female has amber wing bases to beyond arc). Span (set) 52 mm. Hw 26-27 mm, venation, no cross veins in medial space, cubital space (apart from anal crossing) nor subtriangle in fw. Small pt (1.5 mm), subtending one cell below. Elongated postanal cell divided but discoidal area beginning with one cell followed by a row of 3 single cells, and expanding to 8 cells at the hind wing border. **A b d o m e n.** — 26 mm including terminal appendages (female 33 mm); unmarked black but paler at segmental junctions: still black in bright sunshine; cylindrical but expanding to a bottle shape posteriorly, starting at segm. 7, broadest at segm. 8 and 9,

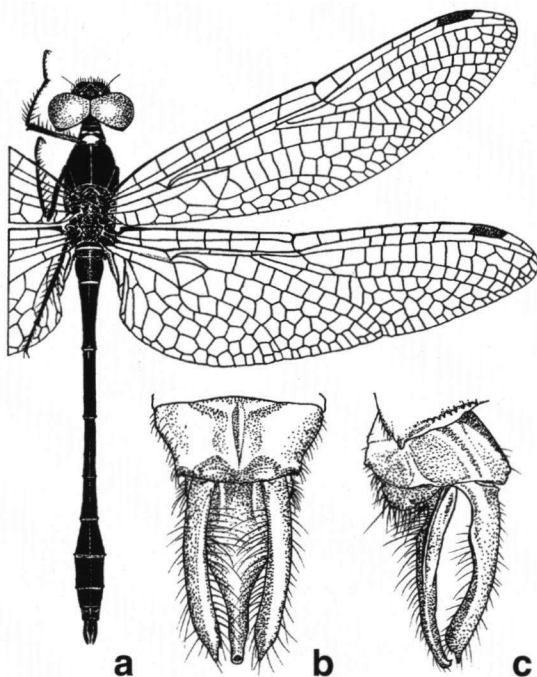


Fig. 3. *Metaphya elongata* Campion, ♂: (a) dorsal view with right-side wings; — (b) terminal appendages, dorsal view; — (c) same, lateral view.

maximum at segm. 9. Appendages, simple (libellulid-like), superiors slightly curved dorsally and laterally, nearly meeting terminally; inferior triangular, just meeting superiors at slightly flattened though somewhat pointed terminus. Thus the male is a short, squat insect compared with the relatively elongate female.

SYNTHEMIS PAMELAE SP. NOV.

Figure 4

Material. – **Holotype** ♂: New Caledonia: Mt Koghis, alt. ca 1000 m, 30 km NW of Nouméa, 9-V-1983, D.A.L. Davies leg; 1 **Allotype** ♀: La Capture, Plaines des Lacs, 50 km S of Nouméa, 3-II-1983, P. Tobin leg. – **Paratypes**: 2 ♂, area of holotype; 1 other material: 1 ♂, Rivière de Kouris, 2-II-1995. All deposited at CUMZ.

Etymology. – Named after the late *Pamela Tobin* who caught the first female which led to the search for males.

MALE (holotype). – Total length 55 mm. – **Head** black except medial lobe of labium brown, upper edge of clypeus whitish and 2 very prominent bright yellow prominences ('eyespots') on protuberances of the frons closely under the compound eyes and adjacent to the outer edges of the shiny black, hairy vertex. – **Prothorax**: dull black, in lateral view, anterior and posterior lobes raised with 'valley' between. – **Pterothorax**: Very dark brown and hairy above; fine pale line on anterior edge and yellow dorsal median line to just short of posterior edge. No antehumeral markings. On sides, a large triangular bright green stripe, broad above and reducing to a point in line with the coxa of the second segment, enclosing the spiracle. A broader, shorter green stripe, tapering downwards over the metepimeron. Legs black, hairy with 9-10 fine spines on the tibia. Wings; span (set), 74 mm, hw. 35 to 38 mm. Venation black, pt black edges with dark brown centre, subtending 3 cells below. Forewings ax 17, px 11 and hw, ax 12 and px 12. Amber colour at base, minimal and extending less than the length of the basal cell. Pattern of venation as in the nearest relative, the well known and much figured *Synthemis miranda* Selys (Fig. 3) and in the definition of Synthemistidae (as tribe Synthemini in TILLYARD, 1917). – **Abdomen**: length 43 mm, including appendages 47 mm. Black, marked with bright green as follows: segm. 1, dorso-lateral light patches, segm. 2 dorso-lateral on anterior third and almost meeting dorsally, segm. 3 mid lateral large spots meeting dorsally, segm. 4 same but spot slightly smaller and angled posteriorly, segm. 5-6 the same, segm. 7 the same but failing to meet dorsally, segm. 8 spots reduced to almost nil, segm. 9 all black, segm. 10 small spots 'fore & aft' and a substantial black dorsal spine curving over posteriorly. Appendages, superiors 4 mm long, begin black but posterior half whitish, inward facing small tubercle just beyond indented whitish area. Inferior appendage dark brown with black edges, tapering from full width to a blunt double narrow end at level of black/white junction of superiors (Fig. 2).

FEMALE (Allotype). – Substantially similar to the male, total length 54 mm, abdomen 40.5 mm. – **Head**: black except for prominent pair of bright yellow spots on tubercles

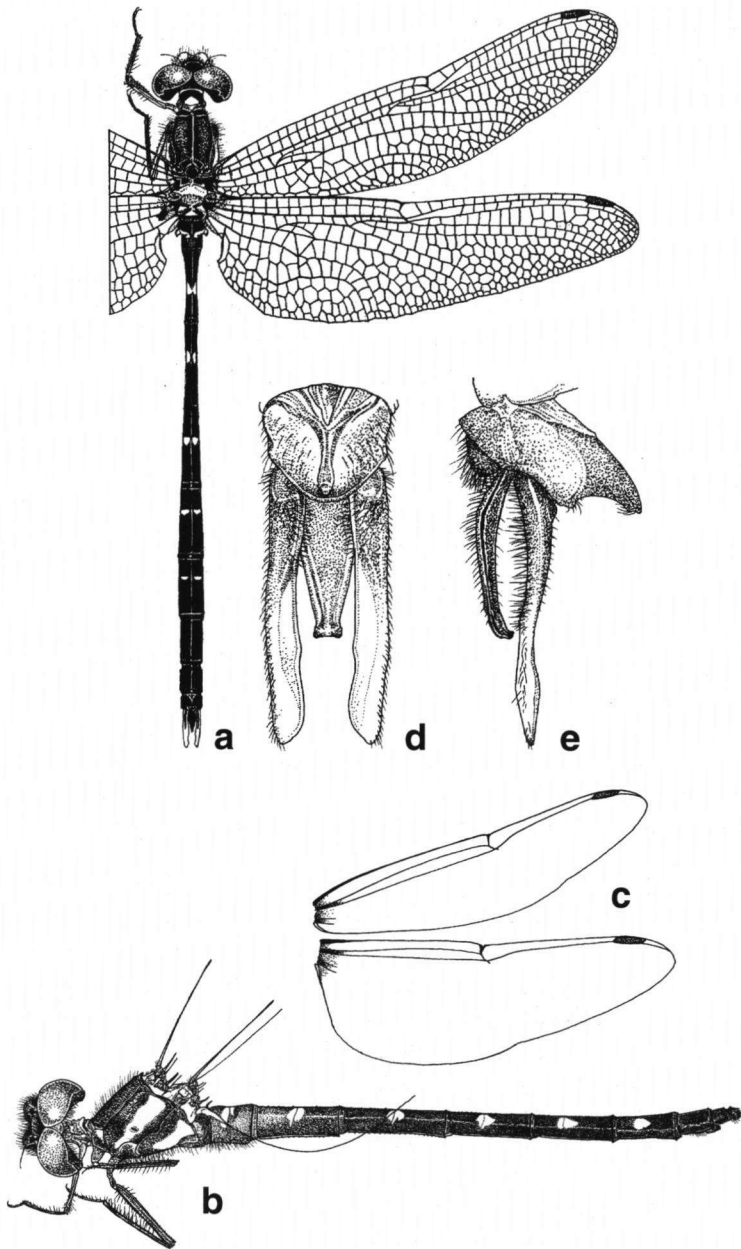


Fig. 4. *Synthemis pamelae* sp. nov.: (a) holotype ♂, dorsal view with right wings; – (b) allotype ♀, lateral view of abdomen; – (c) female right wings, showing extent of pigmentation; – (d) male anal appendages, dorsal view; – (e) same, lateral view.

under the edges of the vertex (as in males). — **T h o r a x**: marked laterally with large triangular green stripes tapering ventrad. Legs black, many hairs, some rows about large enough to be called thin spines. Wings hyaline, basal amber only to 2nd basal crossvein. Fw, ax, 17; px, 11; hw; ax, 12, and px, 12. — **A b d o m e n**: dorso-lateral handsome green patches, small on segm. 2, segm. 3-6 enlarging posteriorly and becoming almost arrow-like analwards; on segm. 7 smaller. None quite meeting on dorsum after segm. 2. Terminal segments black.

VARIATION in males. — Total length 55-60 mm (n = 4).

REMARKS. — The main features that distinguish *S. pamelae* from its nearest relative *Synthemis miranda* are described by CAMPION (1921) and others (see Fig. 5). The latter is a common but spectacular insect, the males are not easily distinguished on the wing from those of *S. pamelae*. In the hand, the single large triangle of green on the thorax is easy to see while the thoracic pattern is quite complex and very different in *S. miranda*. It is interesting that the lateral thoracic pattern is of a style shared only by one other species among N.C. synthemids, i.e. the much smaller *S. ariadne* (see below). The terminal appendages are of the same style but very different in detail, in *S. miranda* there is a pair of strong spines, meeting centrally which are absent from *S. pamelae*. The eyespots on the frons of both sexes of *S. pamelae* are not prominent in *S. miranda* but the latter has 2 more pairs lower down on the face. Females are vastly different, the new species having hyaline wings, while the other species has a much wider wingspan, greater than its own male at 80 to 90 mm and spectacular arcs of gaudy colours from black through orange and yellow up to the nodus, even to a few cells beyond and in the hindwings extending up to 2 thirds of the whole wing area.

SYNTHEMIS SERENDIPITA WINSTANLEY

Figures 5-6a, b

M a t e r i a l. — Allotype ♂: New Caledonia, at 'Sanatorium Creek' close to Paiita (about 25 km NW of Nouméa), 3-II-1983, D.A.L. Davies leg. — Other material: 9 ♂, 2 ♀, taken from the same area. All deposited at CUMZ.

This species was described (WINSTANLEY, 1984a) from a teneral male bred out in New Zealand, from a larva found with other known species collected in central N.C. in December 1981. The 'wild type', a series obtained from near Paiita (25 km N of Nouméa) (D.A.L. Davies & P. Tobin leg.) is of course more sturdy than the bred male and darker brown. Surprisingly these have a wingspan of 60 mm (bred 55 mm), hw 45 (bred 41) and length 76 mm (bred 65). It seems that the diet in a natural stream is more suitable than that to be found in N.Z.! The brown basal patch of the wings is less in wild-type, only to 2 cells (up the Sc).

The females turned out to be probably the largest synthemids so far known, with a wingspan of 10 cm., taken from the same locality as the males already mentioned. Total length 72 mm, abdomen + appendages 57 mm, hw. 48 (n = 4). — **H e a d**: labium

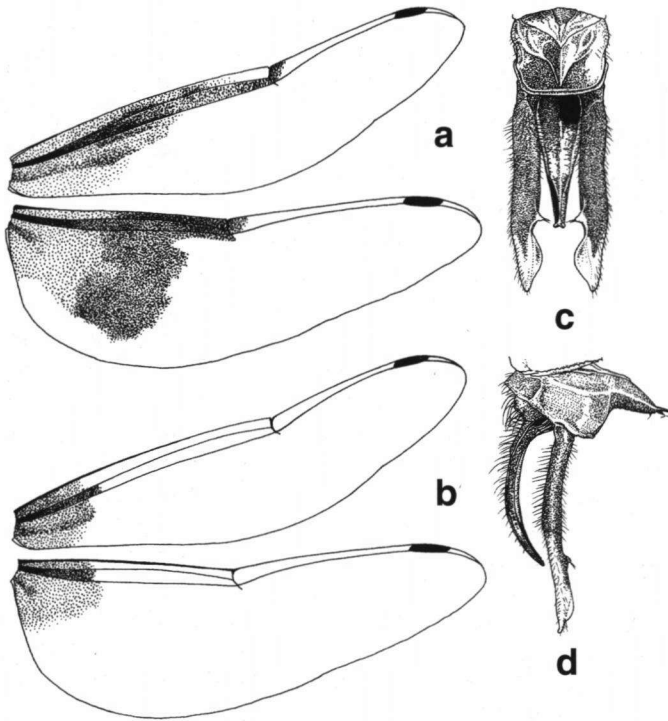


Fig. 5. *Synthemis miranda* Selys: (a) female wings showing area of pigmentation (bright yellow and orange); – (b) ♀, wings of rare and undescribed form with different wing pattern; – (c) male terminal appendages, dorsal view; – (d) same, lateral view.

light brown, clypeus dark brown with darker lower edge; frons dark brown with tubercles lighter; bright light spot centrally in front of vertex, finely hairy. Vertex black with light brown posterior edge; antennae brown. – *Prothorax* light brown. – *Thorax* frontally, even dark brown with green metallic area above; in the position of humeral and lateral stripes are rather obscure lighter ‘stripes’ separated by a shiny green metallic area. Metepimeron dark brown. Wings hyaline but slightly enfumed and with rich brown area at bases extending to 2 or 3 cells beyond arculus; all wings with median space crossed by 5 veins. Female hw. at widest point (outer tip of triangle) 15 mm (male 13 mm). Legs reddish brown, black at joints; 12 spines on femur, otherwise hairs rather than spines. – *Abdomen* even dark brown but with short light yellowish ‘saddle’ marks at centre of dorsum of segm. 2-7, larger on 6 and 7. Terminal appendages simple lanceolate 4 mm long.

For distinction from *S. campioni* (LIEFTINCK, 1971) see Figures 6c-d. Like *S. serendipita*, the former species is a “Gynacantha look-alike” and with generally light brown colouring and both are sun shunning crepusculars. *S. campioni* is overall smaller,

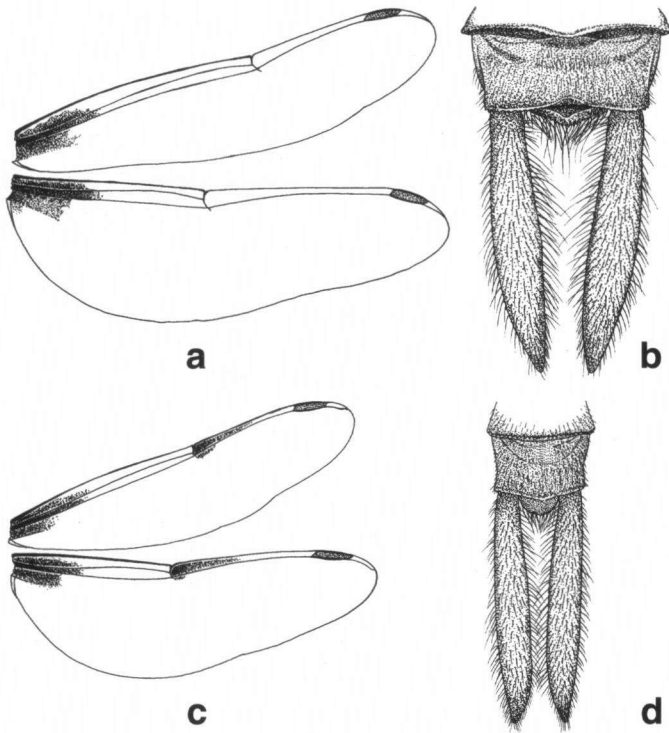


Fig. 6. *Synthemis serendipita* Winstanley (Figs a-b) and *Synthemis campioni* Lieftinck (Figs c-d), females: (a, c) right-side wings (pigmentation in *S. serendipita* bright reddish brown); – (b, d) terminal appendages dorsal view.

about the size of *S. pamela* and the female has dark brown wing patches from wing base to more than half way up to the nodus, and again sharply from the nodus and extending about half way up to pt. Total length 61 mm, hw 44 mm, anal appendages similar to the larger species but only about half the length, 2.5 mm., simple lanceolate and creamy in colour.

ANNOTATED LIST OF THE RESIDENT ODONATA SPECIES IN NEW CALEDONIA

At hand are several lists of the N.C. species. There may be other lists but the first of consequence is that of RIS (1915), providing descriptions of 4 new species and listing 20 species up to that date. A major advance was that of CAMPION (1921), who described 5 new species and listed 26 for the island. The next big step forward was that of LIEFTINCK (1975), who gave descriptions of 5 new species and one subspecies and

a total of 40 species. This paper dealt with imagines. It was followed by another paper (LIEFTINCK, 1976), dealing with the immature stages, and which also included some adult data and the number of different species of larvae exceeded that of species known as adults, e.g. in *Synthemis*! Clearly more species were awaiting discovery. In that paper are also some descriptions of species not in N.C. but included as examples of genera that are represented in N.C.; cursory readers have not only included these in error in N.C. lists, but also omitted a number of new species described in recent years (DOMMANGET, 2000). However, in the meantime a paper by BIGOT (1985) also provided a useful list; 18 species were listed, but the paper covered other orders of insects. One more list deserves attention, that of the 23 species present in the collection of O.R.S.T.O.M (Office de la Recherche Scientifique et Technique Outre-Mer), with interesting species and dates. This is unpublished but data from this is included in the list that follows. F.C. Fraser, who must have visited N.C. at some time, left a printed copy of the species in that collection as a neat little booklet. The species now listed are, to the best of our ability, what we think are based on adequate data and for convenience are put in the order used by LIEFTINCK (1975). For endemic species data for places and dates are included, meagre as they are in some instances. We take it that species found in the South, i.e. the Nouméa area but also in the Koné-Hiéngène area in the Northwest and Northeast respectively, are found throughout the island where suitable niches exist. Thus, rare species are those with limited suitable niches.

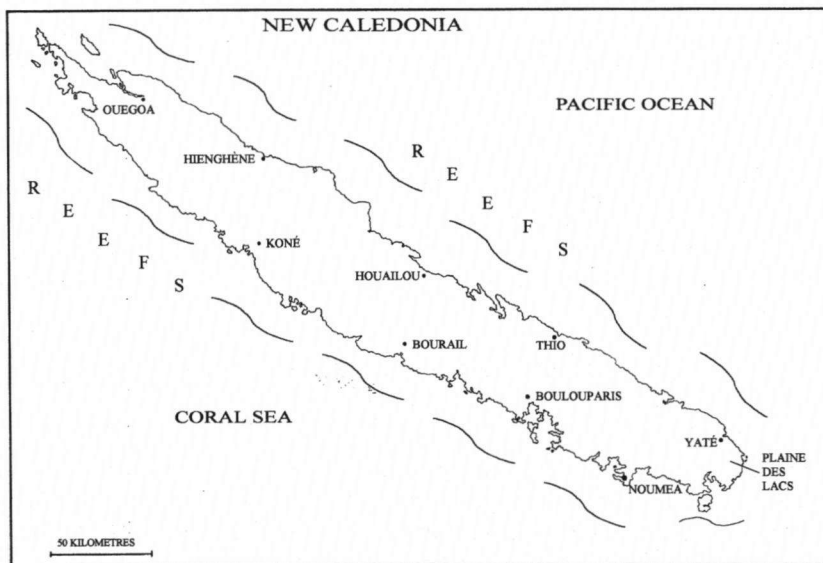


Fig. 7. New Caledonia map, showing places mentioned in text.

LESTIDAE

(1) *Lestes concinnus* Hagen

Common and widespread in N.C. e.g. in the Forêt de Thi and Mt. Koghis (the Nouméa area, i.e. in the South), but also as far North as Koné and Ouegoa. This species has a very wide distribution over SE Asia and Australasia. Most species of the genus have rather restricted areas of coverage and some are quite local. This species is found on islands and other unlikely places, not likely to be due to flying skills but a propensity to drift with the weather and survival ability.

(2) *Lestes (Indolestes) cheesmanae* Kimmins

Has also been in *Austrolestes*. Widespread in N.C., is also in the New Hebrides, where the Type actually came from. It has a very small distribution abroad compared with the last species. From N.C. we have specimens from the Plaine des Lac area in the far South and Koné in the North and dates from January to June.

MEGAPODAGRIONIDAE

(3) *Argiolestes ochraceus* (Montrousier)

Born into *Sympetma*. Endemic and a candidate for the most beautiful damselfly in the World. Quite common throughout N.C. along shaded streams at edges of forests, including those in the Nouméa and Hiéngghène areas. The last segment of the abdomen is enamel blue, penultimate segment black, the rest deep golden. This gold can be enhanced when required into an even deeper colour, e.g. when perched on a leaf in a small sunbeam close to the water with females about. Females relatively unimpressive, larvae with large, flat appendages shaped for rock-clinging. This particular kind of gold colouring occurs in the northeastern Australian species *A. amabilis*, *A. aureus* and *A. chrysoides*.

(4) *Caledopteryx maculata* Winstanley & Davies

Quite a large zygopteran and common around streams, perhaps confined to the area of N.C. only as far North as the road from Boulouparis to Thio or perhaps the West to East road from Bourail to Canala (not on the map), about 50 km further NW. It has a brown abdomen with lighter segmental junctions. Larva with rock holding appendages. This species flies from December (or earlier) well into the autumn.

(5) *Caledopteryx sarasini* (Ris)

Overall similar in style to the last species but more northerly. Heavier in weight and with abdomen all shiny green. Similar habits to the last but flies seemingly only North of the West-East roads referred to above. Common at all suitable rocky streams from October onwards.

(6) *Caledargiolestes janiceae* Lieftinck

The smallest family member in N.C. but rarely seen, perhaps early season, is brown with two dark marks on each segment of the abdomen. At the time of the description only a male was known; here at CUMZ we have a female only, dated 18-II-1983, both specimens were found in southern N.C. between Nouméa and Yaté.

(7) *Caledargiolestes uniseriis* (Ris).

Common and widespread over N.C. from Nouméa to Hiéngghène areas, on forest streams and well known for being identified (WINSTANLEY, 1983), as the supposed 'terrestrial larva' of LIPPIT WILLEY (1955). Breeds in rocky forest streams and their waterfalls on low ground and in mountain areas e.g. Bopop; exuviae left in abundance on rock ledges and muddy edges at riversides. Dates from November to April.

(8) *Trineuragrion percostale* Ris

Common along forest-edge streams. According to LIEFTINCK (1975) the third 'extra' antenodal cross veins are not reliable but sometimes one is missing and thus a variable character for identification. However, at CUMZ, all of 20 specimens do have the three cross veins! Their very

characteristic behaviour patterns are referred to below. Widespread North & South, from November to at least April.

ISOSTICTIDAE

The situation with regard to this family has changed significantly in recent years. *Isosticta* was coined as a genus when it was separated from *Notoneura* and *Nososticta*. All that is history because WATSON et al. (1991) has argued that *Isosticta* is an N.C. genus and Australian species in the genus are unrelated and he has taken these out and put them into new genera. He claims that there is no close relationship between them. This makes *Isosticta* into an endemic N.C. genus. Unfortunately, his new descriptions of species and new allotments to genera are actually published in a book, (strictly an expanded key), which is out of print. If we tacitly accept Watson's opinions, then Isostictidae is a Melanesian family.

(9) *Isosticta spinipes* Selys

Remains the type species and for all of the other species, we have in our collections, male, female and the exuviae upon which they hung, each 'set' is on one pin! awaiting scrutiny. *I. spinipes* is widely distributed over N.C.

(10) *Isosticta tillyardi* Campion

It is common on shallow, stoney rivers. Lieftinck assumed that these fragile little species laid their eggs in the branches of trees and shrubs overhanging streams. This is a favoured habit for e.g. Lestidae. But this time he was far from the truth. One cannot omit to mention one circumstance that is very relevant: on a discouragingly torrentially rainy morning, departure for a forest hunt was tardy, but by mid-morning we were, nevertheless, at the Forêt de Thi. The rain persisted, unabated all day. But on that day, more odonates were seen than on any day in our life's experience. All the isostictas, megapodagrionids, synthemids etc. emerged and those from the earlier days oviposited. Very many species were apprehended sitting on their exuviae, and ended up 'on the same pin'. The isostictas laid, in tandem, at the base of huge boulders at the bottom of waterfalls 'up to their knees' in rushing water! What an extraordinary scene. This also enabled us to associate all the megapodagrionids with their correct exuviae/larvae. This species flies, at least, November to May.

(11) *Isosticta robustior* Ris

Perhaps the most abundant species in the Forêt de Thi. The previous paragraph refers equally to this species.

(12) *Isosticta gracilior* Lieftinck

A few specimens taken, with others at this and other localities, December 1981

(13) *Isosticta humilior* Lieftinck

The same as the above, but February 1983

COENAGRIONIDAE

This family is quite poorly represented in N.C. and, with a few exceptions, perhaps they do not really belong there but have been accidentally introduced by 'civilised' bipedal animals.

(14) *Xanthagrion erythroneurum* (Selys)

A very common Australian damselfly, but recorded from N.C. by KIMMINS (1953), one male specimen from the Nouméa area. However, it is also in the O.R.S.T.O.M. collection (2♂, 1♀). Also seen in our several visits, 1979, 1981, 1983, and 1984 up to the far North.

(15) *Ischnura aurora* (Brauer)

Occurs everywhere in N.C., also from Sri Lanka to Tahiti. This is a very good example of wide distribution achieved by one of the weakest flying odonates, a tiny species that can survive long enough in air-currents across the oceans to establish itself world-wide (Old World so far).

(16) *Ischnura pamela* Vick & Davies

This is another tiny *Ischnura* but in 'conventional' green/blue, unlike the predominantly red (male)

of *I. aurora*. But, the present species appears to be one of the most restricted species known and seems to be confined to the area of the Plaine des Lacs in the south corner of N.C. This species is almost certainly the one noticed by earlier entomologists but remained un-named and undescribed (VICK & DAVIES, 1988).

(17) *Ischnura heterosticta* (Burmeister)

A common and widespread species in all of Australasia and common all over N.C.. The 'subspecies' *I. torresiana* Tillyard, has appeared in earlier lists but WATSON (1976) examined a very large number of specimens from all the sources recorded as homes for '*torresiana*' and from an impressive mass of data decided that such a name was quite unjustified and it has therefore been omitted from this list as a synonym.

(18) *Agriocnemis exudans* Selys

Widespread all over the Island, also including New Hebrides and Fiji, probably another example of wide dispersal due to small size and weak flight.

(19) *Austroagrion watsoni* Lieftinck

A species which now bears this name, was the very well known *A. cyane* Selys, the dominant blue/black damselfly of eastern Australia. When this species turned up in N.C. (in the Nouméa region) in recent times, LIEFTINCK (1982), who was nothing if not thorough, arranged to examine the type of *A. cyane*. It turned out to be what we have been calling *A. coeruleum* Tillyard, which is quite different and confined to SW Australia. In other words, the first such damselfly taken from Australia to Europe came from the Perth area (SWA) and was then assumed to be the same as that subsequently found to be the common species found all over the East of the continent! As *A. coerulea* was clearly a valid name, then old *A. cyane* had to be given a new name, and now is *A. watsoni* Lieftinck. The existence of *A. watsoni* in N.C. was first noted by BIGOT (1985), having perhaps found its way there in the 1970s. As the Coenagrionidae are an 'advanced' group, having climbed to dominance in the largest land-mass in the world, it does seem likely that both *A. watsoni* and *Xanthagrion erythroneurum* appeared in the commercial South of N.C. as 'illegal immigrants' by 'civilised' means otherwise they would surely have consolidated themselves there over the last few million years.

AESHNIDAE

(20) *Oreaeschna dominatrix* Vick & Davies

This species was first encountered at Tango, central N.C. at about 500 m, but was subsequently found, not uncommonly, at low altitudes, even close to sea level. There is only one other species in the genus, that is *O. dictatrix* (LIEFTINCK, 1937) from the Cyclops mountains of New Guinea, hence the name (= 'Mountain Aeshna'). The discovery of this species has somewhat upset the views about old *Aeshna brevistyla* Ramb and its origin. It is likely to be quite frequent in N.C.; CUMZ has specimens dated from February in 1982 to April in 1987.

(21) *Adversaeschna brevistyla caledonica* ssp. n.

This was formerly '*Aeshna brevistyla* Rambur'. The generic name was changed by WATSON (1992) because he decided that the species was not a true *Aeshna* and in particular not related to South American aeshnas (an obsolete hypothesis). He believed that it had some features relating it to *Oreaeschna* as already hinted at by VICK & DAVIES (1990). The form in N.C. has even more features pointing in the direction of *Oreaeschna* and has been given (in this paper) subspecific status. It is rather common all over N.C. through the summer at least.

(22) *Gynacantha rosenberghi* Brauer

Widely spread, even abundant in N.C. Complaints were voiced in Ouegoa (northern N.C.), where an arc lamp lit the little village at night, that the noise of their wings kept people awake; they rushed about in and out of the mass of insects clouded round the high light. Elsewhere found over Australasian and East Indies geographical areas.

(23) *Austrogynacantha heterogena* Tillyard

First seen in N.C. under a row of inverted beer mugs on the bar at a little 'Hotel' at Koné; we, having told Le Maître that we were going to a mountain-side waterfall visible over the forest: 'Pourquoi monsieur?' he added. 'Pour les libellules' we replied. He promised to have some for us by our return (we wondered what to expect!). This and other gynacanthas and some corduliids came to the bar while looking for perches, but slipped accidentally inside through the open slatted windows. Subsequently found also in the Dumbea valley in the far South.

(24) *Anax gibbosulus* Rambur

The most abundant of Anactini in N.C. favouring clearings in wooded country for 'hawking' and common all through the season.

(25) *Anax guttatus* (Burmeister)

Also not uncommon but more in open country. Eight specimens are in the collection of O.R.S.T.O.M.

(26) *Hemianax papuensis* (Burmeister)

Frequently seen in all parts of N.C. in season.

(27) *Anaciaeschna jaspidea* (Burmeister)

Seen occasionally, most sightings being females careering down steep gullies with a male in hot pursuit (guarding her?).

CORDULIIDAE

(28) *Hemicordulia fidelis* McLachlan

Very common and to be seen everywhere in N.C. throughout the season.

(29) *Hemicordulia hilaris* Lieftinck

Much less common than the former species, mostly found in more heavily wooded country. This species is quite difficult to distinguish from *H. oceanica* Selys, which has been listed in error for N.C. This subject has been dealt with by LIEFTINCK (1975), and perhaps this latter species is, in reality, confined to Tahiti!

(30) *Metaphya elongata* Campion

Here, again, we see the inadvisability of naming new species from single specimens, especially from females. The male, described in this paper in not elongate, but is short and squat. The species is quite abundant in the right places at the right times! The South coast from Yaté to Goro seems a favoured locality where they fly, specially round high trees, resting near the tree tops. The species has been reported very recently from further North (KARUBE, 2000), about 20 km NE of Nouméa. The North half of the island, however, has been very little explored compared with the South. CUMZ specimens are dated January and February 1981 and 1983.

SYNTHEMISTIDAE

(31) *Synthemis miranda* Selys

A common species in all wooded areas with a spectacular female having a large area of the wings brown and yellow in the style of a *Chlorogomphus*, which perhaps it mimics in lifestyle. Rumour has it that the species was named from a specimen decorating an elegant lady's hat, and that it was many years before its actual home was discovered to be Melanesia. There is another style of female that has not been reported so far as we know; which has a basal small bright orange colour extending only to about the arculus, about 5 crossveins of the ax series and intensely coloured between Sc and R1. Males flying in company with many of these unusual females seemed true to type. This phenomenon has been encountered only once, along the road between Paiita (25 km NW of Nouméa) and the Sanatorium. These females were properly mature.

(32) *Synthemis pamela* Davies, sp. n.

Seems rare, males flying with those of *S. miranda* are difficult to spot on the wing and only one

female has been found although easily distinguished. Only seen, so far, South of Paiita. The female is smaller than the male and has hyaline wings and very distinctive large green spots along the abdomen.

(33) *Synthemis fenella* Campion

The smallest of the genus in N.C. and quite common along small streams in forests, where it sits on boulders in the streambeds in the style of gomphids. We have dates from November to May in the North and South.

(34) *Synthemis ariadne* Liefstinck

Described from a single male found at Yambie, (between Hiéngghène and Puébo in the far Northeast of N.C.). Found again only twice, in the South of the island; either rare, very local or has been sought out of season. Our dates are October and December. Perhaps 'fussy' about a special niche.

(35) *Synthemis flexicauda* Campion

Perhaps rare, one pair known (at the BMNH, data Nekando, which is about 150 km N of the locality described below), until several males, nearly mistaken for *S. miranda*, were located (April 1984) at a pool along a small tributary of the Dumbéa river, just E of Nouméa. Once caught, easily identified by the most unusual and distinctive terminal appendages of the male. Probably seen elsewhere, but not caught to confirm identification.

(36) *Synthemis montaguei* Campion

Found on our expeditions only sparsely, except once, in good numbers, along the Koniambo river near Koné in February-March 1983. A very handsome species but secretive and has to be searched for along water's edge foliage. Probably seen often when flying but not identified with certainty.

(37) *Synthemis campioni* Liefstinck

Frequent on stony rivers and tends to be crepuscular, thus is coloured pale brown, a 'lightweight' *Gynacantha* 'look-alike'. There are strong but variable brown wingmarks, which are characteristic, from the base of the wing towards the nodus and again from the nodus towards pt. In bright sunshine they rest in shade on riverside foliage often in groups. Widespread throughout the Island. We have dates in December to May.

(38) *Synthemis serendipita* Winstanley

The largest species of *Synthemis* in N.C. with females 10 cm in wingspan; mainly crepuscular and a *Gynacantha* mimic, but not in habits. This species breeds in very shaded stoney rivers and feeds round pools there. Seemingly very local. A good colony is just N of Paiita (November 1983). WINSTANLEY (1984a) found a larva in the Nouméa region, and from which the type male was bred. Possibly seen flying afar but not positively identified.

LIBELLULIDAE

(39) *Agrionoptera insignis* Rambur

Scattered colonies varying in different seasons.

(40) *Orthetrum caledonicum* (Brauer)

Common in all parts of N.C. and widely spread over PNG and Australasia.

(41) *Orthetrum sabina* (Drury)

Common in N.C. and in the Old World except the far West.

(42) *Orthetrum villosiovittatum* (Brauer)

Quite common.

(43) *Lathrecista asiatica festa* (Selys)

'Colonies' here and there varying with season.

(44) *Diplacodes bipunctata* (Brauer)

Sparsely in N.C. in our experience. Abundant over E Asia, Australasia and PNG.

(45) *Diplacodes haematodes* (Burmeister)

Found abundantly over N.C. and otherwise over PNG and Australasia.

- (46) *Rhyothemis graphiptera* (Rambur)
Common everywhere in N.C.
- (47) *Rhyothemis phyllis apicalis* Kirby
A species with very many forms and subspecies in Asia, Australasia and Oceania. It was the opinion of M.A. Lieftinck (pers. comm.) that the Fiji form, *R. phyllis dispar*, should be a separate species and includes the N.C. form (*apicalis*), but this has not been executed in print.
- (48) *Pantala flavescens* Fabricius
Anywhere and everywhere.
- (49) *Tramea loewi* (Brauer)
Widespread over Australasia and PNG, also N.C. *Tramea* are great wanderers, perhaps combining strength of flight with acceptance of atmospheric assistance.
- (50) *Tramea liberata* (Lieftinck)
N.C., otherwise over PNG and Australia.
- (51) *Tramea limbata* (Desjardins)
Well established; specimens in collection O.R.S.T.O.M.
- (52) *Tramea intersecta* (Lieftinck)
An endemic species with a very characteristic wing pattern not found elsewhere. The pattern is very variable in extent but always has the features of the species. Found commonly in N.C. through the season.
- (53) *Macrodiplax cora* (Kaup)
Scattered in time and place throughout N.C. Very characteristic stance on tips of high grasses. Found over E Asia and Oceania.
- (54) *Tholymis tillarga* (Fabricius)
Spectacular sight on lakes at dusk, e.g. in the Dumbéa valley. Found over Old World tropics.
- (55) *Zyxomma petiolatum* Rambur
A great wanderer; found over SE Asia, N Australia and turns up in unlikely places, like N.C.

DISCUSSION

From collected specimens, including single specimens of some species, it will be judged that several more species will eventually be added to the list of residents, perhaps enough to reach 60. There is a *Gynacantha* not on the list that is likely to be *G. dobsoni*, but *G. stenosoni* Fraser, is a possibility; the latter, from Samoa, was described early in Fraser's admirable odonatological career, but the description inadequate. It is difficult to resolve this kind of question.

Among the larvae of *Synthemis* described by LIEFTINCK (1976) are 5 species attributed to the genus but only one allotted (*S. fenella*) and one 'by supposition' (*S. miranda*). Since that time 6 more species have been described as adults, so the discrepancy may have been satisfied.

The danger of suppositions is illustrated by the incorrect allotment of a larva to the supposed terrestrial larva of LIPPIT WILLEY (1955). Thirty years later it was shown to be that of *Caledargiolestes uniseries* by WINSTANLEY (1983). Terrestrial larvae not infrequently disturb the peace. Those who have not been caught in cyclonic rain storms in mountainous forests may not be aware of the extent of sudden flooding (and sudden drainage). Gullies with mountain streams fill quickly to become obscured, as a whole mountainside is flooded and the whereabouts of the gully disappears. The larva

in question was 200 ft from the nearest stream and 100 ft above it and could easily be washed to such a position by a torrent of water and come to no harm as the forest leaf litter never dries enough that it would not sustain a larva, certainly until the next storm! There are many such examples: a larva of the E Australian *Antipodophlebia asthenes*, not previously known, was found under a tree trunk that had fallen across a creek at a horizontal distance of about 50 m, and a vertical distance of about 5-10 m, easily flooded after a storm. However, in this case the species is related to *Telephlebia*, which do have some terrestrial tendencies (WATSON & THEISCHINGER, 1980). It does seem that we have many levels of intermediate behaviour. Terrestrial life for odonate larvae is favoured from study of fossils and suppositions based on their morphology (and hence their physiology). How would we classify *Petalura* in that regard? They feed at the top of their burrows, but collect oxygen from the deep end of their burrows, i.e. fresh water draining down into the nearest streams. (DAVIES, 1998). This accounts for the scatter of 'colonies' of all the Australasian species (and the 3 elsewhere), where the larvae are only found on muddy slopes, usually at streambanks; they are terrestrial and aquatic!

Returning to species on or not on the list, we have a species of *Isosticta* (2 pairs) which is larger and much more robust than *I. robustior* and was found at Forêt de Thi (Nov. 1981). Also, a large female *Hemicordulia* exists that outstandingly outspans that of *H. fidelis*. Contrarily a specimen of *Caledargiolestes* is much smaller than any other specimen in the CUMZ series. No doubt there will be a few others. It should be noted that the expression 'found in the South' does not mean 'not found in the North'; the northerly half of N.C. and especially N. of Koné (on the West) and Hiéngghène (on the East) have been very inadequately explored compared with the much more easily accessible areas around Nouméa and the South e.g. Plaine des Lacs. This latter area has been open-cast mined for nickel and the vegetation has only partially regrown. This same area is short of some minerals, especially phosphorus and potassium and has a relatively impoverished vegetation, which does not seem to have affected the insect fauna. However, some dragonfly species have mainly been found in the North, e.g. *S. montaguei*. But even so, that can not be used as evidence that it is not also abundant in certain localities in the South, in fact the original type male was found at Mt Mou. This may have been near Nouméa in the South, but in the languages of at least some of the native tribes, Mou means 'Mountain', so there are many mount Mous in N.C. With regard to 'illegal immigrants', one wonders whether there were any coenagrionids in N.C. before civilised connections by modern modes of travel existed, (omitting the smallest Zygoptera). Now common SE Asia libellulids are to be seen frequently in the South but are not in the collection held by O.R.S.T.O.M., (now renamed 'IRD Centre de Nouméa, Laboratoire de Zoologie Appliquée'). There are 23 species represented there, all acquired between 1955 and 1962, except one in 1977. Only two coenagrionids are among them, both widespread over the Australasian area (*Xanthagrion erythroneurum* and *Ischnura heterosticta*). Not included in that collection are any of the common libellulids that are now often seen and included in the 'total' listed above,

except *O. caledonicum*, *R. graphiptera*, *D. haematodes* and *D. bipunctata*. Exotic dragonflies often turn up in Europe. In Britain, larvae come in consignments of water plants and flowers for fish-tank decoration. It is very confusing because the dealers do not know where some come from; for example the BMNH had a female libellulid from a dealer in ornamental material for fish fanciers who was sure it was from Malaysia but in fact it was a species confined to Florida. This way, one of the commonest libellulid predators of Asia, *Crocothemis servilia*, arrived in Florida. This species is now widespread there and living on food that the endemic species previously used. How long will it be before the voracious *Orthetrum sabina* arrives in the New World? This species is already in N.C.

Synthemids are specially interesting as a dominant feature of the odonate fauna of N.C., TILLYARD (1917) used Synthemini, i.e. a 'tribe' term. Since then, Syntheminae and later Synthemidae have been used, however current usage is that the family should be Synthemistidae, which has been adopted here. There are about 25 species in 4 regions, southwestern Australia, eastern Australia (some thousands of km away), PNG 9 species and N.C. has 8 species. The latter are as follows, with wing-span (in mm) as set: *S. fenella* (52); *S. ariadne* (56); *S. pamela* (74); *S. flexicauda* (76); *S. campioni* (80); *S. montaguei* (88); *S. miranda* (93); *S. serendipita* (95), female (100). These figures do not tell us much because their habits have not been studied sufficiently. *S. fenella* has the gomphid-like habit of perching on stones and boulders in mid stream. LIEFTINCK (1976) describes its larva as rather gomphid-like in style. WINSTANLEY (1984b) described the larva of *S. ariadne* from a good number of specimens (supposition with a good backing), and described it as similar to that of *S. fenella*. As figured, it is short and flat and might also occupy a gomphid-like niche. It is very noticeable that there are no gomphids in N.C., a topic to be returned to later. Thus a 'gomphid-like niche' was once available into which some odonate could adapt. This seems very plausible. *S. campioni* is very gynacanthoid in style and behaviour; *S. serendipita* is a *Gynacantha*-mimic in appearance and style of habitat, but not in style of feeding. In any case gynacanthas themselves have found, and are well established, in N.C. *S. miranda* does appear to have a lifestyle in both sexes like chlorogomphids, a family not found on the island; perhaps that is their niche, the female having gaudy large gliding wings. *S. ariadne* might also be in a gomphid-like niche but has been observed only a few times; it does fly up small, quite fast running streams (also seen along dry stream beds). *S. pamela*, *S. flexicauda* and *S. montaguei* may be filling the libellulid or smaller aeshnid places in the hierarchy. This is largely imaginative, the point is that there have seemed to be gaps (niches) to fill, which implies a 'starting point' and it is widely accepted that was post-Oligocene. There are no ancient relic species in N.C. i.e. pre-Tertiary. The expanded endemic genera seem to have filled what appear to have been vacant niches.

Where did these early colonists come from? Presumably from E Australia and / or PNG; these species have apparently been superseded in Eurasia by more recently evolved forms, especially libellulids and aeshnids. The libellulids have now 'found' N.C. and are doing very well there, perhaps it is easier to get there now, especially by assisted

passage. But the synthemids are very well adapted and entrenched over a long period of geological time and persist safely in the forested areas.

The megapodagrionids are also very well settled in, and are still in PNG and east Australia, especially in Queensland, (FRASER, 1960), but the N.C. species are a 'polyglot' collection; only the genera *Caledopteryx* and *Caledargiolestes* have two closely related species each. They could also be post-Tertiary, including *Trineuragrion* and *A. ochraceus*; and how did their ancestors reach the island? A one in a million chance is not too much to expect with 45 million years in hand. However, that far back in time, Australia with PNG 'attached' were very much nearer to N.C. than they are now and this land-mass group was very much further away from Malaya and the SE Asia plus Europe block. Also Australia may have been too cold at that time and if there was a north-westerly prevailing weather pattern, that would have favoured PNG as a source. Furthermore, for those of us who favour the 'expanding earth' mechanism to account for continental drift (OWEN, 1983), PNG could have been much nearer still to N.C. (CAREY, 1970, 1983).

Because the isostictas have been separated from the Australian Protoneuridae anyway, it is helpful that LIEFTINCK (1953) chose the PNG endemic species *Selysionura cornelia* as the nearest relative, morphologically, to the N.C. Isostictidae. The same source (PNG) could have provided some of the megapodagrionids.

We have to conclude that the dominant powerful fliers will have 'found their own way' to N.C. (with storms to help?) but in much more recent millennia, because they are not distinguishable from their nominate specific forms i.e. the species now extant in the geneal area of SE Asia and the Indonesian archipelago.

A source for *Adversaeschna brevistyla* we cannot guess, but it seems to have given rise to the 2 *Oreaeschna* species independently. Indeed, the N.C. species has some of the generic characters more markedly developed than the genotype. *Anax gibbosulus* and *A. guttatus*, and the other N.C. Anactini must have come in the same way, niches for the largest predators still being 'vacant'. Recall that in our present times, *Hemianax ephippiger*, a species in the same size class, has flown safely from the Mediterranean area to Iceland and sympetrum fly annually from Africa to N Europe and are similar in style to the diplacodes of E Asia, specimens of which are already in the O.R.S.T.O.M. collection in Nouméa.

An interesting topic is how the Zygoptera sort themselves out over different parts of a stream, as though there was once a 'sterile' stream along which space waited to be shared out! For a particular stream we have studied, hundreds of others will be along the west coast draining from the hilly forests down ever decreasing slopes to the sea. Starting, e.g. at a high waterfall (15-25 or more m), the water will fall onto large boulders and perhaps make a pool below. Here isostictas live and oviposit, as already described, and *Caledopteryx* will fly around. At intermediate falls (5-10 m) the water will typically flow down into deep pools, with smooth rock sides. Here *A. ochraceus* will breed and leave its exuviae on the rocky sides of the pool. Small 'falls' (a metre or less) will customarily be watched over by a male *Trineuragrion*, perched on the nearest

large stone above the pool below, in which the female will be busy ovipositing. Thus, these species rarely meet for territorial arguments. Between medium and small falls, stretches of varying slope and speed of water flow run over rocky, pebbly, gravelly or sandy beds. In the first, *Caledargiolestes uniseries* will occupy space; pebbly will have *Caledopteryx maculata* or *C. sarasini*. Sandy will have hemicordulias and other Anisoptera but synthemids prefer more bouldery, open, wider but shallow rivers. More of these patterns will emerge with careful watching.

The success of recently evolved 'advanced' libellulids and others seems to be due to wide adaptability, especially to poorly oxygenated still water; that is a physiological advance. This is the kind of water that peopled places mainly provide. The old forest species have such a need for highly oxygenated water that they will go to any lengths to find it. A 'park' in an N.C. forest was provided with 'conveniences' and a small (about 4 m wide) concrete dam provided the water. An overflow a few cm below the top edge provided a spout of water, round which 4 large odonate larvae were clinging to the outside of the concrete in the rush of water, anchored as on a rock. The secret of really long survival for ancient species is thus dependent on the survival of the forests with their fast running drainage channels, large and small. Even natural lakes are evanescent as geological features, they first fill with mud and then silt and then debris until plants can grow and re-establish 'dry' land, eventually trees again. A local example is a large glacial morrain lake about 10,000 years of age which is now a very fine, flat area of heathland with willow and other shrubs and small pools, an ideal locality for leucorrhinias.

Finally what about gomphids as there are none in N.C. Yet SE Asia excels with its variety of gomphids, having 35 genera. Malaysia has far less, with just 52 species recorded in his masterpiece by LIEFTINCK (1954). In the equally masterful series on Papua-New Guinea is an impressive mass of data but only in Part VI are Gomphidae mentioned, and then only an *Ictinogomphus*. (LIEFTINCK, 1942). In Australia, there is a good variety of gomphids, (38 spp.) but mainly small, and with fast flight though not long sustained. It is not certain where they came from but probably from S America. Perhaps that is the answer, there are none in New Guinea. So it seems that the gomphids also did not cross the 'Wallace Line' and find N.C.

ACKNOWLEDGEMENTS

The most recent call for thanks goes to my friend Mr RAY ANDRESS for preparing and executing the figures with the highest quality and accomplishment, using only my sketches and also help with graphics from DENISE FROST. Those who explored with me, (after a 'recce' alone in 1979), were BILL WINSTANLEY (N.Z.), in 1981; the 'all seeing' PAMELA TOBIN in 1983 and Dr NEVILLE YATES (Caloundra, Queensland) in 1984, and thanks to him also for the loan of his 1984 diary! Each trip had its highlights and each produced new, undescribed species. They overlapped in time to extend from November (1981) to May (1984). I thank Dr JEAN GUTIERREZ and Dr JEAN CHAZEAU of (the then) O.R.S.T.O.M., for accommodation and help with '4-WD' vehicles. These gentlemen again helped recently with finding the detailed data for the collection of Odonata held by O.R.S.T.O.M., noted by me as 23 species in 1981; this latter item was assisted by Mrs LYDIA BONNET DE LARBOGNE. Finally, EUNICE BACON I

thank for constant encouragement, the boring proof reading and beating the PC for me when it misbehaved.

REFERENCES

- BIGOT, L., 1985. Contributions à l'étude des peuplements littoraux et cotiers de la Nouvelle-Calédonie (Grand Terre, Ile des Pins) et d'une des Iles Loyauté (Ouvéa): premier inventaire entomologique. *Annls Soc. ent. Fr.* (N.S.). 21(3): 317-329.
- BROTHERS, R.N. & A.R. LILLIE., 1988. Regional geology of New Caledonia, In: A.E.M. Naern, [Eds], The Ocean basins and margins, 7B: The Pacific Ocean, Plenum Press, New York-London.
- CAMPION, H., 1921. Odonata collected in New Caledonia by the late Mr Paul Montague. *Ann. Mag. nat. Hist.* (IX) 8: 33-67.
- CAREY, S.W., 1970. Australia, New Guinea and Melanesia in the current revolution of concepts of the evolution of the earth. *Search*, Sydney 1(5): 178-189.
- CAREY, S.W., [Ed.], 1983. *The expanding Earth*. Univ. Tasmania, Hobart.
- COOK, J., 1999. *The journals of captain Cook*. Penguin Classics, London.
- DAVIES, D.A.L., 1998. The genus *Petalura*: field observations, habits and conservation status (Anisoptera: Petaluridae). *Odonatologica* 27(3): 287-305.
- DOMMANGET, J.-L., 2000. Liste provisoire des odonates de la Nouvelle-Calédonie. *Martinia* 16(3): 142-144.
- FRASER, F.C., 1960. *A handbook of the dragonflies of Australasia*. Roy. Zool. Soc. NSW, Sydney.
- KARUBE, H., 2000. Records of the New Caledonian Odonata. *Aeschna* 37: 37-42. 1 [Japanese]
- KIMMINS, D.E., 1953. Miss L.E. Cheesman's expedition to New Caledonia 1949. *Ann. Mag. nat. Hist.* (XII) 6: 241-257.
- LIEFTINCK, M.A., 1937. The dragonflies (Odonata) of New Guinea and neighbouring islands. 4. Descriptions of new and little known species. *Nova Guinea* 1: 1-82.
- LIEFTINCK, M.A., 1942. The dragonflies (Odonata) of New Guinea and neighbouring islands. 6. *Treubia* 18: 441-608.
- LIEFTINCK, M.A., 1953. The larval characters of the Protoneuridae, with special reference to *Selysionneura* Foerster. *Treubia* 21: 541-684.
- LIEFTINCK, M.A., 1954. Handlist of Malasian Odonata. *Treubia* 22 (Suppl.): 1-202.
- LIEFTINCK, M.A., 1971. Studies in oriental Corduliidae (Odonata). *Tijdsch. Ent.* 114: 1-63.
- LIEFTINCK, M.A., 1975. The dragonflies (Odonata) of New Caledonia and the Loyalty Islands, 1: Imagines. *Cah. Office Rech. scient. techn. Outre-Mer* (Hydrobiol.) 9(2): 127-166.
- LIEFTINCK, M.A., 1976. The dragonflies (Odonata) of New Caledonia and the Loyalty Islands, 2: Immature stages. *Cah. Office Rech. scient. techn. Outre-Mer* (Hydrobiol.) 10(2): 165-200.
- LIEFTINCK, M.A., 1982. Settling up matters of taxonomy, nomenclature and synonymy in the genus *Austroagrion* (Zygoptera: Coenagrionidae). *Odonatologica* 11(4): 287-295.
- LILLEY, A.R. & R.N. BROTHERS, 1969. The geology of New Caledonia. *N. Z. J. Geol. Geophys.* 13(1): 145-183.
- LIPPITT WILLEY, R., 1955. A terrestrial damselfly nymph (Megapodagrionidae) from New Caledonia. *Psyche* 62(4): 137-144.
- MONTAGUE, P., 1914. [Unpublished data; his collection was presented later to the BMNH by the collector's mother]
- MONTRousIER, R.P., 1865. Essai sur la faune entomologique de Kanala (Nouvelle-Calédonie) et description de quelques espèces nouvelles ou peu connues. *Ann. Soc. linn. Lyon.* (N.S.) 11: 46-257.
- OWEN, H.G., 1983. *Atlas of continental displacement, 200 million years to the present*. Cambridge Univ. Press, Cambridge, UK.
- PETERS, A., 1989. *Atlas of the World*. Longmans, Harlow, UK.
- RISS, F., 1915. Libellen (Odonata) von neu-Calédonien und den Loyalty-Inseln. In: F. Sarasin & J. Roux, *Nova Caledonia* (Zool.) 2(14): 57-72, Kreidel, Wiesbaden.

- TILLYARD, R.J., 1916. Life histories and description of Australian Aeshninae. *J. linn. Soc. Lond. (Zool.)* 33: 1-84.
- TILLYARD, R.J., 1917. *The biology of dragonflies*. Cambridge Univ. Press, Cambridge, UK.
- VICK, G.S. & D.A.L. DAVIES, 1988. A new species of *Ischnura* from New Caledonia (Zygoptera: Coenagrionidae). *Odonatologica* 17(3): 281-287.
- VICK, G.S. & D.A.L. DAVIES, 1990. A new species of *Oreaeschna* from New Caledonia (Anisoptera: Aeshnidae). *Odonatologica* 19(2): 187-194.
- WATSON, J.A.L., 1976. The synonymy of *Ischnura heterosticta* Burm. and *Ischnura torresiana* Till. *J. Aust. ent. Soc.* 15: 71-78.
- WATSON, J.A.L., 1992. The affinities of *Aeshna brevistyla* Rambur (Anisoptera: Aeshnidae). *Odonatologica* 21(4): 453-471.
- WATSON, J.A.L. & G. THEISCHINGER, 1980. The larva of *Antipodophlebia asthenes* (Tillyard): a terrestrial dragonfly? (Anisoptera: Aeshnidae). *Odonatologica* 9(3): 253-258.
- WATSON, J.A.L., G. THEISCHINGER & H.M. ABBEY, 1991. *The Australian dragonflies*. C.S.I.R.O., Canberra.
- WINSTANLEY, W.J., 1983. Terrestrial larvae of Odonata from New Caledonia (Anisoptera: Synthemistidae). *Odonatologica* 12(4): 389-395.
- WINSTANLEY, W.J., 1984a. *Synthemis serendipita* sp. nov. (Odonata: Synthemistidae) from New Caledonia. *N. Z. J. Zool.* 11: 9-12.
- WINSTANLEY, W.J., 1984b. The larva of the New Caledonian endemic dragonfly *Synthemis ariadne* Liefstinck (Anisoptera: Synthemistidae). *Odonatologica* 13(1): 159-164.
- WINSTANLEY, W.J. & D.A.L. DAVIES, 1992. *Caledopteryx maculata* sp. nov. from New Caledonia (Zygoptera: Megapodagrionidae). *Odonatologica* 11(4): 339-346.