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Distribution, habitats, phenology and conservation of New Caledonian Odonata

Abstract

Compared to other archipelagos of the Pacific, the New Caledonian Odonata fauna is rich and diverse with 56 valid species or subspecies (23 endemics, 41%) from eight families (four Zygoptera: Argiolestidae, Coenagrionidae, Isostictidae, Lestidae, and four Anisoptera: Aeshnidae, Corduliidae, Synthemistidae, Libellulidae) and 31 genera (including four endemics, 13%). In Zygoptera, we record 19 species including 12 endemics (63%), and among Anisoptera, we record 37 species or subspecies, including 11 endemics (30%). we removed five species from the list that had been erroneously recorded as occurring in New Caledonia: *Tramea carolina* (Linnaeus, 1763), *Austroargiolestes icteromelas* (Selys-Longchamps, 1862), *Ischnura torresiana* Tillyard, 1913, *Xiphiagrion cyanomelas* Selys-Longchamps, 1876 and *Hemicordulia oceanica* Selys-Longchamps, 1871. The occurrence of *Tramea limbata* (Desjardins, 1835) appears also doubtful, but we were unable to clarify to which taxon this record referred hence we excluded it from our update. From a biogeographic perspective, the New Caledonian fauna has mostly Australian affinities with some connections with southeast Asia and the Pacific region. we provide for each species, whenever information was available, a distribution map with a brief review of its known ecology, behaviour and phenology. we also evaluated each species' conservation status, in light of known threats (range restriction, scarcity and human activity including altered water flow). we consider seventeen species (30%) endangered. The most immediate threats concern water pollution including alteration to the flow of water courses caused by mining, deforestation and fires. Invasive species, such as alien fish, may be predators of concern for odonata larva, although this has not yet been proven in New Caledonia.

Key words: Odonata, distribution, endemism, conservation, threats

Résumé

Par rapport aux autres archipels du Pacifique, la faune des Odonates de Nouvelle-Calédonie est riche et diversifiée avec 56 espèces ou sous-espèces valides (23 espèces endémiques, 41 %) de huit familles (quatre de Zygoptères: Argiolestidae, Coenagrionidae, Isostictidae, Lestidae et quatre d'Anisoptères: Aeshnidae, Corduliidae, Synthemistidae, Libellulidae) et 31 genres (dont quatre endémiques, 13 %). Parmi les Zygoptères, nous comptons 19 taxa dont 12 endémiques (63%). Parmi les Anisoptères, nous comptons 37 espèces ou sous-espèces, dont 11 endémiques (30%). Nous avons retiré 5 espèces de la liste faunistique de Nouvelle-Calédonie, celles-ci ayant été attribuées de façon erronée à l'archipel: *Tramea carolina* (Linnaeus, 1763), *Austroargiolestes icteromelas* (Selys-Longchamps, 1862), *Ischnura torresiana* Tillyard, 1913, *Xiphiagrion cyanomelas* Selys-Longchamps, 1876 et *Hemicordulia oceanica* Selys-Longchamps, 1871. *Tramea limbata* (Desjardins, 1835) est une mention douteuse et n'a pas été incluse dans cet inventaire, faute d'une clarification de l'identité du taxon concerné. Cette faune montre de très nettes affinités biogéographiques avec l'Australie, avec quelques influences du sud-est asiatique et de la région Pacifique. Pour chaque espèce, nous proposons une carte de distribution et une synthèse des données disponibles sur l'écologie, l'éthologie et la phénologie. Pour chacune des espèces, nous proposons une évaluation du niveau de menaces (en fonction de leur distribution, de leur rareté et des menaces consécutives aux activités humaines) et un statut provisoire. Dix-sept espèces (30%) sont considérées en danger d'extinction. Les menaces les plus immédiates concernent la pollution des cours d'eau notamment par l'activité minière, la déforestation et les incendies qui changent le régime d'écoulements des cours d'eau. Des espèces envahissantes, comme les poissons exotiques, peuvent être prédateurs importants pour les larves d'odonates, bien que cela n'ait pas encore été prouvé en Nouvelle-Calédonie.

Introduction

Damselflies and dragonflies (Order Odonata, hereafter dragonflies or odonates) are considered one of the oldest insect groups and occur in most regions of the world, especially in the tropics (Corbet & Brooks 2008). Almost all

odonate larvae live in freshwater habitats, whereas the adults are terrestrial, often spending much time on the wing (Suhling *et al.* 2015). In both life stages they require specific physical and chemical conditions to survive and tend to react quickly to any alteration of their natural environment (Marinov *et al.* 2013). Because of their dual habitat lifestyle, dragonflies are considered worldwide as important indicators of the health of terrestrial-aquatic environments, which has significance in conservation management (Kalkman *et al.* 2008). Being a relatively small and well known insect order, odonates were one of the first insect groups to be globally assessed (Clausnitzer *et al.* 2009). There are approximately 6,200 species of odonates known worldwide (Schorr & Paulson 2018). Within the Pacific region, New Caledonia is characterized by a high level of endemism on a relatively small surface (18,000 km²) for many groups of organisms (Grandcolas *et al.* 2008). Our objective was to provide detailed information on distribution, habitat, behaviour and phenology of resident odonate species over the whole archipelago. We also evaluated their conservation status according to known threats.

Material and methods

Our study area comprises the entire New Caledonian archipelago (Fig. 1), which consists of the main island (Grande Terre), the Belep islands, the Isle of Pines (Île des Pins) and the Loyalty Islands (Ouvéa, Lifou, Maré and Tiga). For this study area, we compiled a database of our own unpublished data and literature records (total area coverage in Fig. 1). This enabled us to compile the most comprehensive review on New Caledonian Odonata fauna to date, map species distribution and retrieve information about the biology, ecology and phenology of each species. We list Odonata species in chronological order as they have been reported for New Caledonia (Table 1). Each species is represented with the original published species name followed by the currently accepted name, verbatim locality information, literature source and page number. Species new to science described from New Caledonia are marked with “*”. Most of the recently collected specimens were preserved in ethanol (70%) while others were pinned and deposited as voucher specimens in either the private collection of one of the authors (DG), the collection held at the Institut de Recherches et de Développement in Nouméa, New Caledonia (abbreviated as ONNC), the collection of the Institut Agronomique néo-Calédonien, Station de Recherche Agronomique de Pocquereux in La Foa, New Caledonia (CXMNC) or the New Zealand Arthropod Collection (NZAC), Auckland, New Zealand. We did not check Odonata specimens deposited at other collections, e.g. the Cambridge University Museum of Zoology (holding material by the late Allen Davies), because of the unfortunate death of the first author (DG) in 2012. After his tragic departure, we (the remaining authors) decided to finish the manuscript and follow the original design as closely as possible. All photos that we used for illustration without mentioning the author were from DG’s personal photo archive. We provided the name of authors and country of origin (for non endemic species) in case the photos came from another source and were not taken in New Caledonia.

Although we included in the species distribution maps as many unpublished records shared with us by other odonatologists (see acknowledgements) as possible, we were not able to include all remaining unpublished and unreviewed material in the paper.

Most of the recent collecting effort was focussed on endemic species that have been little studied. DG undertook systematic research in January–February 2004, February 2010, February–March 2011, and October–November 2011, and MM in January 2009 and October 2010. HJ, SR, CM, and JT carried out additional opportunistic sampling between 1999 and 2016.

We assess the taxonomic status of each species and following Lieftinck (1975), Tsuda (2000) and Schorr & Paulson (2018), outline its world range, map the local distribution and summarise data on larval biology, adult behaviour and flight period. We also evaluate threats and propose an IUCN category for each species. The latter is based on an evaluation of distribution area, the known recorded localities, population abundances (when assessed) and the level of anthropogenic threats to their habitats. We used the IUCN’s abbreviations for the suggested conservation status, namely: Data Deficient (DD) Least Concern (LC), Near Threatened (NT), Vulnerable (VU), Endangered (EN), and Critically Endangered (CR). We define a local endemic as a species only recorded on the New Caledonian archipelago and a regional endemic as a species restricted to New Caledonia, Vanuatu and Fiji.

Table 1. Odonata fauna of New Caledonia arranged chronologically with the original published binomial name, the currently valid binomial name, locality of first New Caledonian record, literature source and page (species described as new to science based on holotypes from New Caledonia are marked with an asterisk after the valid species name).

No	Original binomial name	Valid binomial name	Locality	Reference	Page
1	<i>Sympecma ochracea</i>	<i>Eoargiolestes ochraceus</i> *	Nouvelle-Calédonie	Montrouzier (1864)	247
2	<i>Libellula (Diplax) bipunctata</i> nov. sp.	<i>Diplacodes bipunctata</i> *	Taiti; Nova Caledonia	Brauer (1865a)	503
3	<i>Libellula caledonica</i> n. sp.	<i>Orthetrum caledonicum</i> *	Nova Caledonia	Brauer (1865a)	505
4	<i>Synthemis miranda</i>	<i>Synthemis miranda</i> *	Nouvelle-Calédonie	Selys-Longchamps (1871)	557
5	<i>Ischnura heterosticta</i>	<i>Ischnura heterosticta</i>	Nouvelle-Calédonie	Selys-Longchamps (1876)	271
6	<i>Agriocnemis exsudans</i>	<i>Agriocnemis exsudans</i> *	Nouvelle-Calédonie	Selys-Longchamps (1877)	148
7	<i>Tramea loewii</i>	<i>Tramea loewii</i>	Nov. Caledonia?	Selys-Longchamps (1878)	293
8	<i>Isosticta spinipes</i>	<i>Isosticta spinipes</i> *	Nouvelle-Calédonie	Selys-Longchamps (1885)	7
9	<i>Hemicordulia fidelis</i>	<i>Hemicordulia fidelis</i> *	Uvea, Loyalty Islands	McLachlan (1886)	104
10	<i>Pantala flavescens</i>	<i>Pantala flavescens</i>	Nouvelle-Calédonie	Martin (1901)	221
11	<i>Rhyothemis apicalis</i>	<i>Rhyothemis phyllis apicalis</i>	Nouvelle-Calédonie	Martin (1901)	221
12	<i>Rhyothemis graphiptera</i>	<i>Rhyothemis graphiptera</i>	Nouvelle-Calédonie	Martin (1901)	221
13	<i>Agrionoptera insignis allogenae</i>	<i>Agrionoptera insignis</i>	Neu Caledonien	Ris (1909-1919)	142
14	<i>Diplacodes haematodes</i>	<i>Diplacodes haematodes</i>	N. Calédonie	Ris (1909-1919)	473
15	<i>Argiolestes sarasini</i>	<i>Caledopteryx sarasini</i> *	Canala	Ris (1915)	58
16	<i>Argiolestes uniseriis</i>	<i>Caledargiolestes uniseriis</i> *	Canala	Ris (1915)	62
17	<i>Trineuragrion percostale</i>	<i>Trineuragrion percostale</i> *	Oubatche, Canala	Ris (1915)	63
18	<i>Isosticta robustior</i>	<i>Isosticta robustior</i> *	Oubatche, Lifou	Ris (1915)	66
19	<i>Ischnura aurora</i>	<i>Ischnura aurora</i>	Canala	Ris (1915)	67
20	<i>Aeschna brevistyla</i>	<i>Aeshna brevistyla caledonica</i>	Yaté	Ris (1915)	67
21	<i>Isosticta tillyardi</i>	<i>Isosticta tillyardi</i> *	Mt. Canala	Campion (1921)	38
22	<i>Synthemis montaguei</i>	<i>Synthemis montaguei</i> *	Mt. Mou	Campion (1921)	55
23	<i>Synthemis flexicauda</i>	<i>Synthemis flexicauda</i> *	Mt. Nekando	Campion (1921)	57
24	<i>Synthemis fenella</i>	<i>Synthemis fenella</i> *	Mt. Mou	Campion (1921)	61
25	<i>Metaphya elongata</i>	<i>Metaphya elongata</i> *	Baie Ngo	Campion (1921)	64
26	<i>Austrolestes cheesmanae</i>	<i>Indolestes cheesmanae</i>	Pouébo; Nouméa	Kimmins (1953)	242
27	<i>Xanthagrion erythroneurum</i>	<i>Xanthagrion erythroneurum</i>	Nouméa	Kimmins (1953)	242
28	<i>Acanthagyna rosenbergi</i>	<i>Gynacantha rosenbergi</i>	Pouébo	Kimmins (1953)	243
29	<i>Anax gibbosulus</i>	<i>Anax gibbosulus</i>	New Caledonia	Kimmins (1958)	248
30	<i>Synthemis campioni</i>	<i>Synthemis campioni</i> *	Pouébo; Mt. Mou	Lieftinck (1971)	48
31	<i>Lestes concinnus</i>	<i>Lestes concinnus</i>	Yahoue, Nouméa, St. Louis	Lieftinck (1975)	133
32	<i>Caledargiolestes janiceae</i>	<i>Caledargiolestes janiceae</i> *	Mt. Pouédihi	Lieftinck (1975)	141
33	<i>Isosticta gracilior</i>	<i>Isosticta gracilior</i> *	River Bleue	Lieftinck (1975)	148

.....continued on the next page

Table 1. (Continued)

No	Original binomial name	Valid binomial name	Locality	Reference	Page
34	<i>Isosticta humilior</i>	<i>Isosticta humilior</i> *	near La Foa, Couli	Lieftinck (1975)	149
35	<i>Hemicordulia hilaris</i>	<i>Hemicordulia hilaris</i> *	New Caledonia	Lieftinck (1975)	154
36	<i>Synthemis ariadne</i>	<i>Synthemis ariadne</i> *	Yiambe	Lieftinck (1975)	160
37	<i>Lathrecista asiatica festa</i>	<i>Lathrecista asiatica festa</i>	Yiambe	Lieftinck (1975)	161
38	<i>Tramea liberata liberata</i>	<i>Tramea liberata liberata</i>	Plum	Lieftinck (1975)	164
39	<i>Tramea transmarina intersecta</i>	<i>Tramea transmarina intersecta</i> *	New Caledonia	Lieftinck (1975)	162
40	<i>Austroagrion watsoni</i>	<i>Austroagrion watsoni</i>	Plaine des Lacs, Grand Lac	Lieftinck (1982)	293
41	<i>Caledopteryx maculata</i>	<i>Caledopteryx maculata</i> *	Trib. Rivière des Pirogues, Terr. Rte; Forêt de Thi	winstanley & Davies (1982)	339-346
42	<i>Anaciaeschna jaspidea</i>	<i>Anaciaeschna jaspidea</i>	Ouégoa; Nouvelle Calédonie; Nouméa	winstanley & Davies (1983)	31
43	<i>Anax guttatus</i>	<i>Anax guttatus</i>	Nouvelle Calédonie; Nouméa, Ansa Vata	winstanley & Davies (1983)	31
44	<i>Hemianax papuensis</i>	<i>Anax papuensis</i>	Nouméa	winstanley & Davies (1983)	31
45	<i>Macrodiplax cora</i>	<i>Macrodiplax cora</i>	Nouméa	winstanley & Davies (1983)	31
46	<i>Tholymis tillarga</i>	<i>Tholymis tillarga</i>	Houailou; ex large pond at Ouégoa	winstanley & Davies (1983)	31
47	<i>Synthemis serendipita</i>	<i>Synthemis serendipita</i> *	Col d'Amieu	winstanley (1984b)	9-12
48	<i>Ischnura pamela</i>	<i>Ischnura pamela</i> *	Plaine des Lacs	Vick & Davies (1988)	281-287
49	<i>Oreaeschna dominatrix</i>	<i>Oreaeschna dominatrix</i> *	Plateau de Tango; Plaine des Lacs	Vick & Davies (1990)	187-194
50	<i>Synthemis pamela</i>	<i>Synthemis pamela</i> *	New Caledonia, Mt Koghis, alt. 1000 m, 30 km Nw of Nouméa	Davies (2002)	234
51	<i>Austrogynacantha heterogena</i>	<i>Austrogynacantha heterogena</i>	Koné	Davies (2002)	243
52	<i>Orthetrum sabina</i>	<i>Orthetrum serapia/sabina</i>	New Caledonia	Davies (2002)	244
53	<i>Orthetrum villosovittatum</i>	<i>Orthetrum villosovittatum</i>	New Caledonia	Davies (2002)	244
54	<i>Zyxomma petiolatum</i>	<i>Zyxomma petiolatum</i>	New Caledonia	Davies (2002)	245
55	<i>Neurothemis stigmatizans</i>	<i>Neurothemis stigmatizans</i>	New Caledonia	Grand (2004a)	140
56	<i>Diplacodes trivialis</i>	<i>Diplacodes trivialis</i>	Ouvéa	Grand <i>et al.</i> (2014)	252

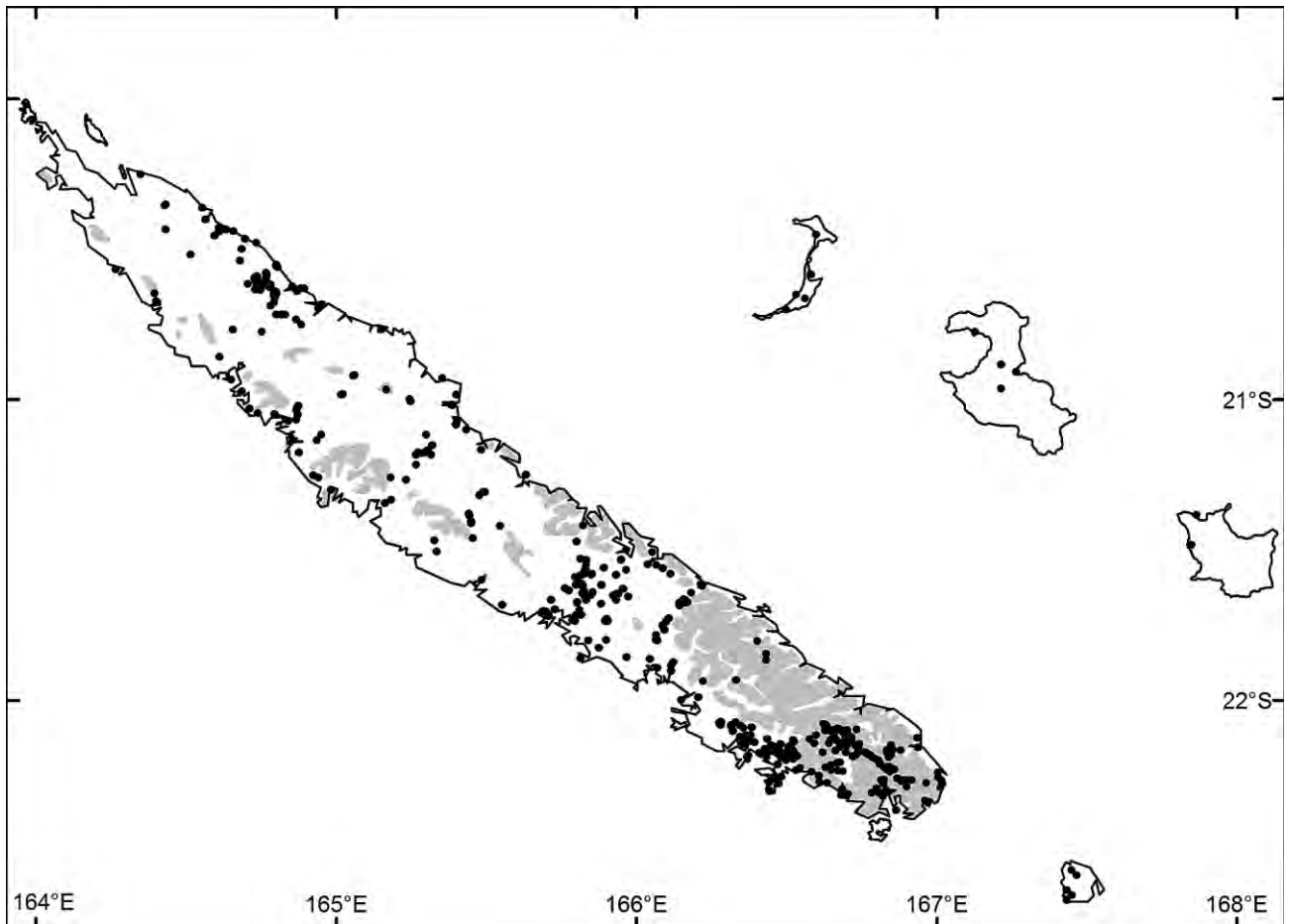


Figure 1. All Odonata records for New Caledonia (this study and literature sources). The grey area represents the distribution of ultramafic soil.

Results

History of Odonata research in New Caledonia. The Marist Reverend-Father Xavier Montrouzier was the first to provide information on New Caledonian Odonata. In Perroud & Montrouzier (1864), there is a short description of *Sympecma ochracea* from Canala. Recently, Kalkman & Theischinger (2013) transferred the species to Argiolestidae and erected the monotypic genus *Eoargiolestes* for this New Caledonian endemic. Brauer (1864) recorded three species but, to this day, we have been unable to trace them: *Libellula* sp. nov. (Nova Caledonia), *Diplax* sp.? (Nova Caledonia) 1 ♀ without a species name provided, and *Tramea carolina* L. (Neucaledonien) 1 ♂. The latter has not been sampled since and has been almost completely omitted from almost all subsequent reviews on New Caledonian fauna, with only Tepper (1899) recording this species from New Caledonia. The body colour, and the colour and shape of the dark patch in the hind-wing of *Tramea carolina* (Linnaeus, 1763) are similar to those of *T. transmarina* Brauer, 1867, a species known to occur in New Caledonia, which may have misled Brauer in his initial identification. Moreover *T. carolina* is otherwise known only from Canada and the USA (Needham *et al.* 2000), well removed from the Pacific Islands. Therefore, *T. carolina* is removed from the New Caledonian fauna list.

Brauer (1865a, b) described two new species from New Caledonia one of which was also found in Tahiti (Table 1), both being recorded again by Brauer (1868). During the next two decades, six species, including four new to science, were added to the fauna by Selys-Longchamps (1871, 1876, 1877, 1878, 1885, 1886), who provided detailed redescriptions of named species from the island, and McLachlan (1886) (cf. Table 1). Shortly after, Kirby (1890) included six New Caledonian species in his Synonymic Catalogue of the world Odonata.

The beginning of the twentieth century saw increased activity in the study of New Caledonian Odonata, although most publications constituted general reviews of particular families or of larger geographic areas with notes

on species' world distributions (Martin 1901, 1906, 1914; Tillyard 1910; Ris 1909–1919). These studies added five species to the archipelago's check list (Table 1). Although Martin (1906) reported *Hemicordulia oceanica* Selys-Longchamps, 1871 from New Caledonia and this species was subsequently included in the checklist compiled by Ris (1913) and Campion (1921), Lieftinck (1975) recognised it as a new species, *H. hilaris* (Table 1), and subsequently removed *H. oceanica* from the New Caledonian faunal list. Lieftinck (1975) also transferred New Caledonian specimens previously reported as *Tramea limbata* (Desjardins, 1835) to *T. transmarina* and described a new subspecies, *T. transmarina intersecta*.

The first comprehensive revisions of New Caledonian Odonata were published respectively by Ris (1915) and Campion (1921), with detailed morphological descriptions, excellent illustrations and precise body measurements. In addition, Ris (1915) provided the first attempt to analyse the New Caledonian Odonata fauna in relation to that of other Pacific Islands, and Campion (1921) compiled the first identification key to difficult genera including *Isosticta* Selys-Longchamps, 1885. Together these two authors added 11 species, including four (Ris) and five (Campion) new to science (Table 1).

Following these major works, several opportunistic field samples were included in taxonomic as well as faunistic research reports. Kennedy (1925) created two new endemic genera (*Caledargiolestes* and *Caledopteryx*) for *Argiolestes uniseries* Ris, 1915 and *Argiolestes sarasini* Ris, 1915, respectively, endemics which had been described by Ris (1915). Cheesman (1927) recorded *Anax gibbosulus* Rambur, 1842 for the island, although Schmidt (1938a) questioned this record as no supporting data were available at this time. Schmidt (1938b) also briefly queried the anecdotal nature of the discovery of the type specimen of *Synthemis miranda* Selys-Longchamps, 1871, first recorded in Tillyard (1910). Marinov & Richards (2013) commented on this case and suggested disregarding any further discussions around it.

Kimmins (1953) described *Agrionoptera insignis lifuana* from the Loyalty Islands. It is, however, excluded from Table 1 because Lieftinck (1975) considered that the New Caledonian specimens were closer to *Agrionoptera papuensis* Selys-Longchamps, 1879 and suggested using the name *A. p. lifuana* Kimmins, 1953 instead. This view has not been supported by successive researchers, who have all referred New Caledonian specimens to *A. insignis* (Rambur, 1842). Until further taxonomic revision is provided, the latter name should be used for the archipelago.

L.E. Cheesman's expeditions in the Pacific region produced a small collection of interesting Odonata taxa, which was reported by Kimmins (1953, 1958). This added four species to the checklist of the archipelago (Table 1). Kimmins (1953) also listed *Xiphiagrion cyanomelas* Selys-Longchamps, 1876 from Lifou, but Lieftinck (1975) noted that the species had not been confirmed for the New Caledonian main island. Because we have no evidence of subsequent records, it is not included in Table 1.

Between the 1950s and 1960s, there were few publications with information on the Odonata of New Caledonia. Lipitt-willey (1955) reported terrestrial habits of a larva (*Argiolestes* sp.), which winstanley (1983) consequently associated with *Caledargiolestes uniseries*. Lieftinck (1960) briefly reported on a species already known from the island, *Indolestes cheesmanae* (Kimmins, 1936). Tokunaga (1961) documented three ectoparasitic midges of the genus *Forcipomyia* Meigen, 1818 (Diptera: Ceratopogonidae) of *Orthetrum caledonicum* (Brauer, 1865), and Starmühlner (1968) listed the Odonata larvae (identified to suborder level only) sampled during the Austrian-New Caledonian expedition of the Zoological Institute of the University of Vienna.

In the 1970s, Lieftinck opened a new chapter in studies of New Caledonian Odonata. During the research on Oriental Corduliidae, Lieftinck (1971) paid special attention to the New Caledonian genus *Synthemis* Selys-Longchamps, 1870, summarising what was known. He provided a key to adults and gave morphological details of larvae of two species (by supposition). One of the species treated in this work was described as new to science (*Synthemis campioni* Lieftinck, 1971). Lieftinck (1975, 1976) published the most comprehensive studies on New Caledonian Odonata to date, focusing on adults and larvae respectively. His works resulted in nine taxa (seven species and two subspecies) being added to the archipelago's fauna list with six (five species and one subspecies) being new to science. These papers increased the known Odonata fauna to 40 taxa, including both *Ischnura heterosticta* (Burmeister, 1839) and *I. torresiana* Tillyard, 1913. However, watson (1976) synonymised *I. torresiana* with *I. heterosticta*. we therefore excluded *I. torresiana* from Table 1. The vast material analysed during Lieftinck's studies and the identification keys and illustrations that he presented serve to this date as a guide to people interested in New Caledonian Odonata. Lieftinck described *Austroagrion watsoni* Lieftinck, 1982 largely based on material from Australia, but also reported it from one locality in New Caledonia.

For the following 20 years, winstanley & Davies (1982, 1983), winstanley (1983, 1984a, b, c), Vick & Davies

(1988, 1990), and Davies (1990, 2002) carried out detailed analyses of the New Caledonian Odonata. Sixteen taxa (fifteen species and one subspecies) were added to the archipelago's known fauna with six of them (five species and one subspecies) new to science (winstanley 1984b; winstanley & Davies 1982; Vick & Davies 1988, 1990; Davies 2002).

winstanley (1983) provided important ecological and biological information and discussed the larval habitats of several species. winstanley (1984a) also described the larva (by supposition) of an endemic species (*Synthemis ariadne* Lieftinck, 1975) and made comments on its observed ecological peculiarities. winstanley (1984c) and Davies (1990) described the events surrounding recent discoveries. winstanley (1984c) reported on recent discoveries of two new species: "*Caledopteryx maculata* (winstanley and Davies) and *Ischnura mesembrine* winstanley (holotypes Bishop Museum)". The first species was indeed described in winstanley & Davies (1982), however, the destiny of *I. mesembrine* is uncertain. winstanley (1984c) provided a short diagnosis but we were unable to find any formal description of this species and no specimen is kept in the Bishop Museum (D. Polhemus per. comm.). Therefore, we treat this as nomen nudum and did not include the species in Table 1.

In the more recent papers specifically dealing with New Caledonian Odonata, Kitagawa (1990) and Karube (2000) reported on results of field trips to the island; Grand (2004a) reported the at present second to last species added to the New Caledonian Odonata fauna (which brought the total list up to 55); Fleck (2005, 2007) described the larvae of *Synthemis ariadne* (by supposition) and *Metaphya elongata* Campion, 1921 respectively; Papazian & Mary-Sasal (2010) described the male of a previously known subspecies (*Rhyothemis phyllis apicalis* Kirby, 1889); Marinov (2012a) described the larva of *Trineuragrion percostale* Ris, 1915 and also mapped the world distribution of the genus *Hemicordulia* Selys-Longchamps, 1870 including New Caledonian representatives (Marinov 2012b); Michalski (2013) provided a short travel report on an Odonata field trip New Caledonia; Marinov & Richards (2013) recognised a new female colour form of *Synthemis miranda*; Marinov *et al.* (2013) summarised the results of a Rapid Assessment Programme within Mt. Panié, NE part of the island and Grand *et al.* (2014) published a key to adults of all 56 species known from the archipelago. The latter was amended in Grand *et al.* (2018) with a modification of the key to *Caledargiolestes* species.

New Caledonian Odonata have been considered in several other investigations, which can be grouped as follows: a) species checklists for French overseas departments and territories (Dommanget 2000; Dommanget & Mashaal 2000, 2002; Meurgey 2004; Grand 2006); b) taxonomic and phylogenetic studies (Kalkman *et al.* 2010a, b; Kalkman & Theischinger 2013; Dijkstra *et al.* 2014), c) general overviews for conservation purposes (Rowe 2004; Grand 2005); d) museum and private collections (Voisin 2001; Papazian 2002); e) hydrobiological studies (Mary 1999, 2002, 2017; Pöllabauer *et al.* 2005); f) studies on invertebrates that include Odonata (Bigot 1985; Jourdan & Mille 2006); g) studies over larger regions that encompass New Caledonia (Lieftinck 1959; Starmühlner 1986); h) general species distribution (Endersby 2002), and i) a bibliography checklist (Chazeau 1995). However, some of these publications should be treated with caution considering their use of nomenclature and the unknown accuracy of their identifications. Dommanget (2000) and Meurgey (2004) used nomenclature that is generally compatible with that suggested by Davies (2002). However, four species must be removed from their lists: *Austroargiolestes icteromelas* (Selys-Longchamps, 1862), *Ischnura torresiana*, *Xiphiagrion cyanomelas* and *Hemicordulia oceanica*. Grand (2006) commented upon the first two species and removed them from the checklist, whereas he retained *X. cyanomelas*. we no longer consider this species and *H. oceanica* are part of the New Caledonian Odonata fauna (cf. comments given above). Grand (2006) published in a compilation of articles presenting images of the Odonata species discovered in French overseas territories. The image showing *Caledopteryx sarasini* from Mont Mou is in fact its close relative *C. maculata*, which is the only species from the genus so far known from that mountain. Pöllabauer *et al.* (2005) published another checklist that erroneously contains the above mentioned *I. torresiana* and *X. cyanomelas* along with *Agrionoptera papuensis*, which currently is treated as *A. insignis* (see above). Fleck & El Adouzi (2013) compiled a generic key to larvae of Synthemistidae excluding the New Caledonian endemic species which were considered as in need of revision.

Annotated list of species

ZYGoptera

Family Argiolestidae Kalkman & Theischinger, 2013

Argiolestidae were raised to family level by Kalkmann & Theischinger (2013) and include all zygopteran genera in which the gills of the larvae are flat and held in a horizontal plane. The family is divided into two subfamilies based on characters of the penis in the adult male, Argiolestinae and Podolestinae, with the Argiolestinae only found in Australasia and Sulawesi. Podolestinae are represented in New Caledonia by four genera, which are all endemic to the archipelago.

***Caledargiolestes janiceae* Lieftinck, 1975**

(photo not available)

Caledargiolestes janiceae Lieftinck, 1975: 141.

Distribution (Fig. 2). Endemic to Grande Terre where it is restricted to a small area in the south. The type locality of the holotype male is Mont Pouédihi, 15 km to the west of the Forest Station of Ouénarou (Lieftinck 1975). winstanley (1984c) reported a female sampled in November–December 1981. The last record is from Davies (2002) who gave ‘road from Nouméa to Yaté’ as the site of capture, with no other details. Most probably this record would have been collected in the 1980s (A. Orr pers. comm.).

Habitats. The semi-adult male holotype of *C. janiceae* was collected in a stream at an altitude of 153 m. The precise habitat of this specimen has not been described. Its biology and behaviour are unknown.

Status. Despite targeted searches during the second half of February 2011, this extremely rare Grande Terre endemic was found neither at Mont Pouédihi nor along the streams crossing the road from Nouméa to Yaté. The absence could have been due to the lateness of the searches. we suspect the most favourable period would have been from the second half of November to the end of January. *Caledargiolestes janiceae* must be considered as CR.

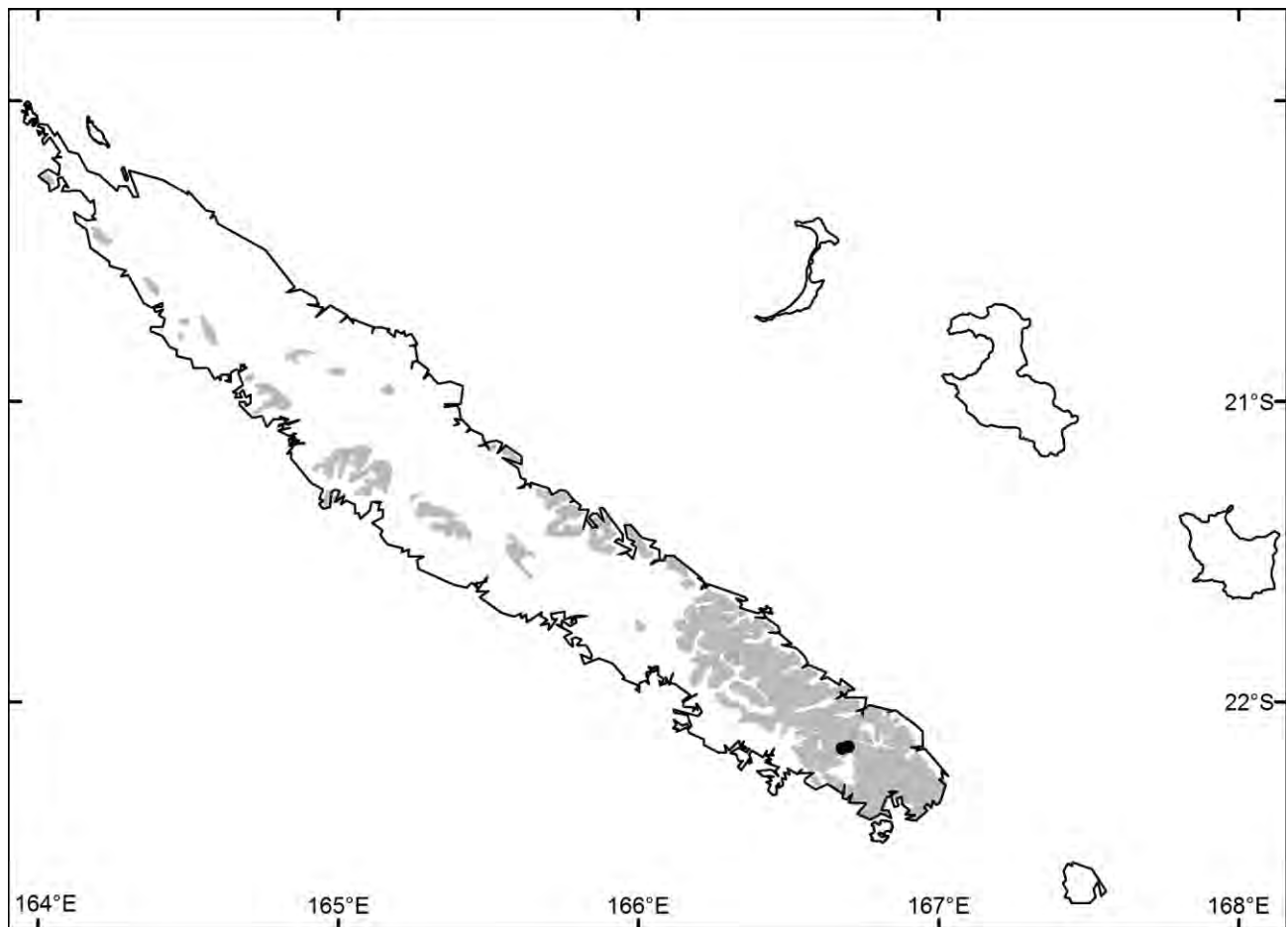


FIGURE 2. Records of *Caledargiolestes janiceae*.

Caledargiolestes uniseries (Ris, 1915)

(Fig. 3)

Argiolestes uniseries Ris, 1915: 62.



FIGURE 3. *Caledargiolestes uniseries*: a) male, b) female.

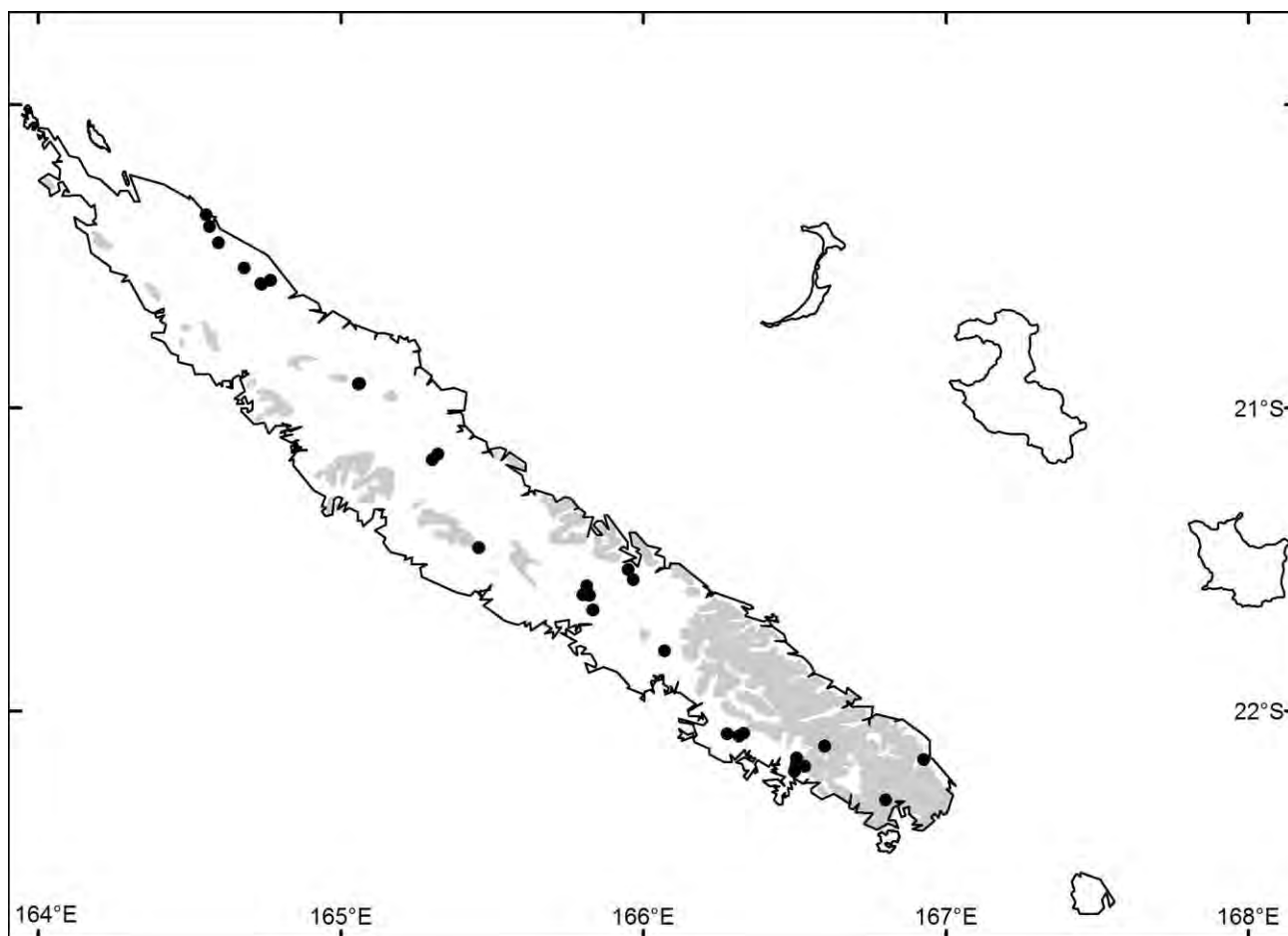


Figure 4. Records of *Caledargiolestes uniseriis*.

Distribution (Fig. 4). Endemic to Grande Terre. This species is widely distributed and easily observed, it was recorded from at least 20 localities.

Habitat. *Caledargiolestes uniseriis* lives around creeks and small streams in hilly forests. It also occurs in oozings of very strong currents.

biology and behaviour. The larva of *C. uniseriis* was first discovered by Lippitt willey (1955), but not properly identified. It was reported as a Megapodagrionidae larva found in leaf litter, which suggested a potential non-aquatic, burrowing lifestyle. Lieftinck (1976) failed to correctly associate the larva to the adult and what he described as *C. uniseriis* (by supposition) was in fact the larva of *Trineuragrion percostale* (Marinov 2012a). winstanley (1983) correctly associated the larva of *C. uniseriis* by comparing photographs and detailed drawings presented by both Lippitt willey (1955) and Lieftinck (1976). He reared larvae in laboratory conditions, where he could observe the emergence of three individuals and documented details about the foraging behaviour of larvae in the absence of free water. The author concluded that larvae of this species “thrive rather than survive in a situation frequently lacking free water, and they are normally terrestrial, although the rearing experiments also permit the view that they are amphibious” (winstanley 1983).

In natural conditions emergences are sometimes during the morning, because a dead teneral lying close to its exuvia was found around 06:00 h, near water. The last larval stages of *C. uniseriis* were considered as “terrestrial” by Lippitt willey (1955), as some larvae were collected in forest litter. Adults remain around creeks and males do not appear to be territorial.

Status. This species has a wide distribution within its range with sometimes large populations. However, deforestation and mud pollution of creeks are posing significant threats, hence *C. uniseriis* is considered as NT.

***Caledopteryx maculata* Winstanley & Davies, 1982**

(Fig. 5)

Caledopteryx maculata winstanley & Davies, 1982: 340.



FIGURE 5. *Caledopteryx maculata*: a) male, b) female.

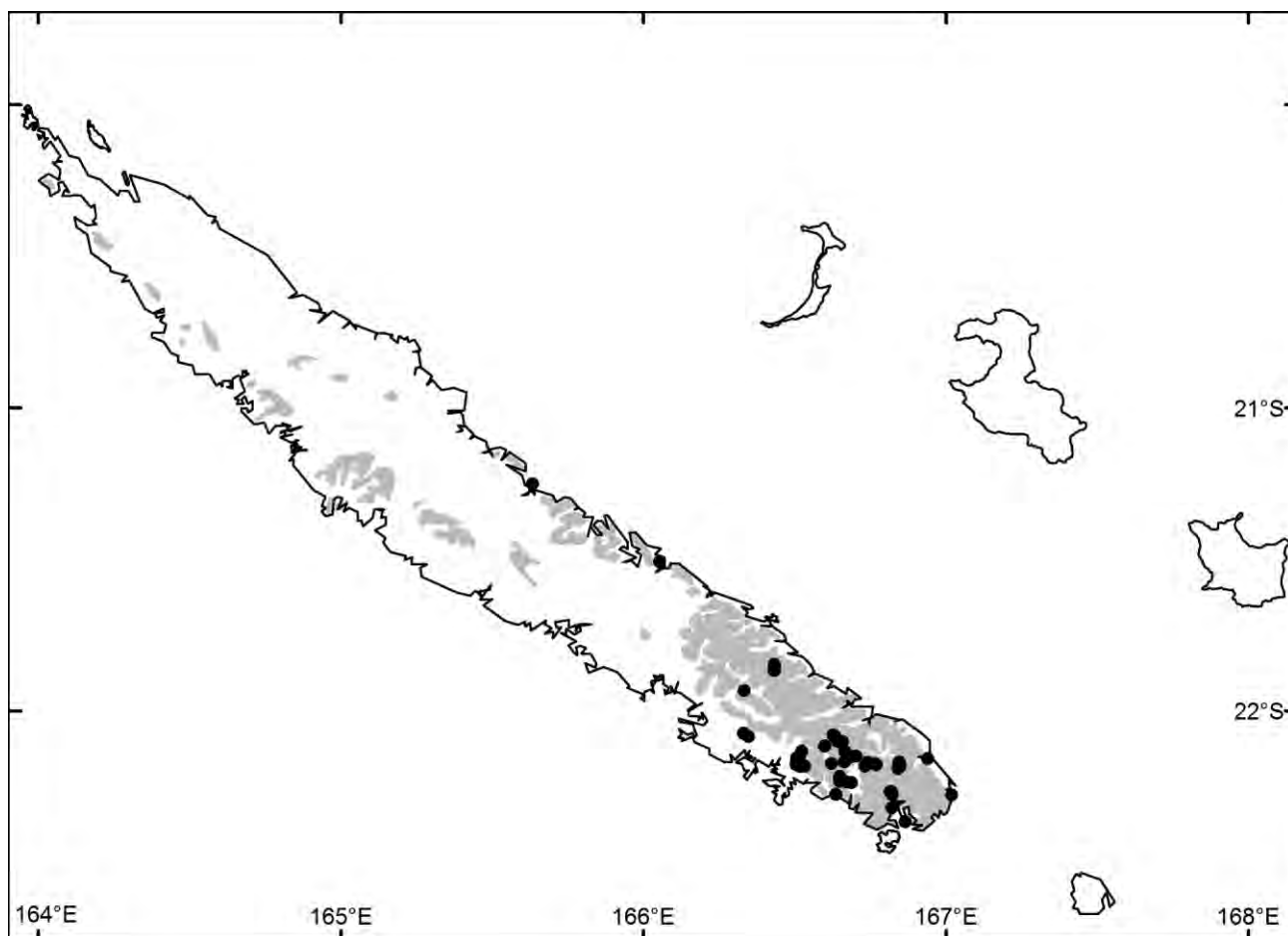


Figure 6. Records of *Caledopteryx maculata*.

Distribution (Fig. 6). Endemic to Grande Terre. This species reaches 80 mm in wing span. It is recorded from more than 20 known localities, most of them on ultramafic soils in the south of the island. It is however recorded regularly from central New Caledonia sympatrically (winstanley & Davies 1982) with the more northern *Caledopteryx sarasini*, a very similar species. For years *C. maculata* was confused with *C. sarasini*.

Habitats. *Caledopteryx maculata* especially occurs in mid and upper parts of rocky bottomed creeks and small forest streams.

biology and behaviour. Larvae may survive at low water levels, remaining under moss on vertical rocky walls through which water seeps. The adults emerge in the morning a few cm above the water surface in places with a strong current, the larvae having often climbed from under a rock. One individual emerged around 12:45 h, in mid February 2011, on a rock in the creek near the Sanatorium, at the Col de la Pirogue near Païta. It was splashed by water, but this did not prevent it from taking flight 15 min later. Adults can fly far away from water. Several maturing individuals were observed on the way to the Pic Malaoui, at an altitude of 700 m. winstanley & Davies (1982) reported males settling horizontally on prominent perches overlooking potential oviposition sites and often returning to the same perching site if disturbed. However, they appear to be non-territorial and often rest on vegetation along creek banks. Mating, which can occur just before sunset (observed once at 18:45 h) lasts more than twenty minutes.

Status. This species occurs mostly on ultramafic soils of the southern quarter of Grande Terre where it is threatened by bushfires. Because of its restricted distribution, *C. maculata* must be considered as NT.

Caledopteryx sarasini (Ris, 1915)

(Fig. 7)

Argiolestes sarasini Ris, 1915: 58.



7a



7b

Figure 7. *Caledopteryx sarasini*: a) male, b) female.

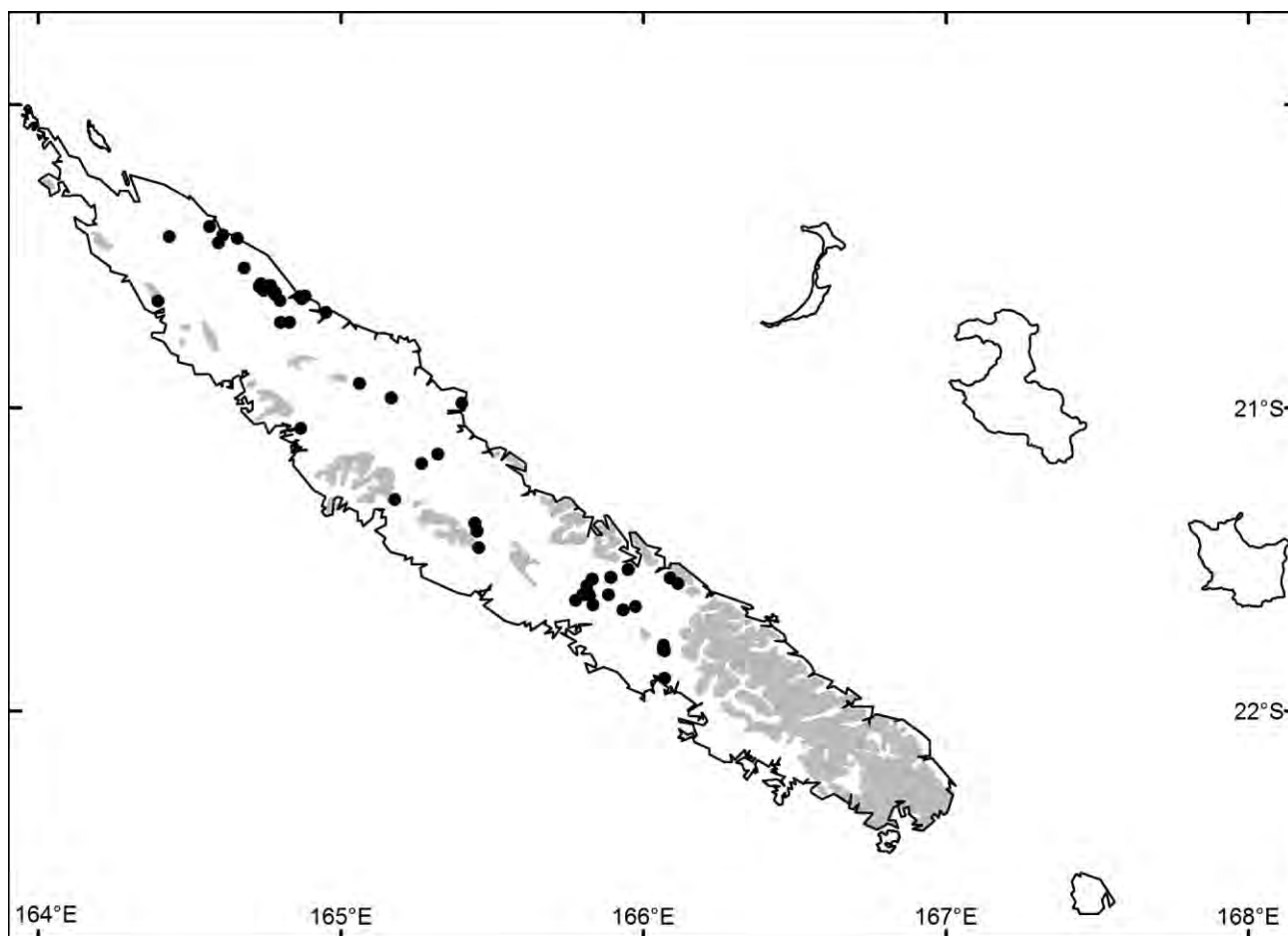


Figure 8. Records of *Caledopteryx sarasini*.

Distribution (Fig. 8). Genus endemic to Grande Terre. This species is known from the northern two thirds of the island, its distribution overlapping in part that of *C. maculata*. More than 30 localities have been recorded.

Habitats. *Caledopteryx sarasini* lives in the same habitats as *C. maculata*, namely mountain creeks in forested areas, almost always on non-ultramafic soils.

biology and behaviour. The larva was described by Lieftink (1976). Its behaviour is similar to that of *C. maculata*, which was described by winstanley & Davies (1982).

Status. This species prefers mountainous forest areas. Its habitats are threatened by bushfires. According, we considered it as NT.

***Eoargiolestes ochraceus* (Montrouzier, 1864)**

(Fig. 9)

Sympetma ochracea Montrouzier, 1864: 247; *Argiolestes rouxi* Ris, 1915, *Argiolestes ochraceus* (Montrouzier, 1864).

Distribution (Fig. 10). Genus endemic to Grande Terre. More than 30 localities are known from all over the island.

Habitats. *Eoargiolestes ochraceus* prefers creeks with sunny reaches, on moderate slopes and with a rocky bed. It is rarer in the shaded upper parts of mountain creeks.

biology and behaviour. Larvae were described by Lieftinck (1976). Exuviae are found very close to the water, generally less than 20 cm from the water surface. Males are territorial and remain perched for long periods on rocks near the water surface. They drive off other males venturing into their territory.

Status. This species is widely distributed, with large populations. The main threat to its survival is the pollution of creeks and rivers. we consider this species to be LC.



Figure 9. *Eoargiolestes ochraceus*: a) male, b) female.

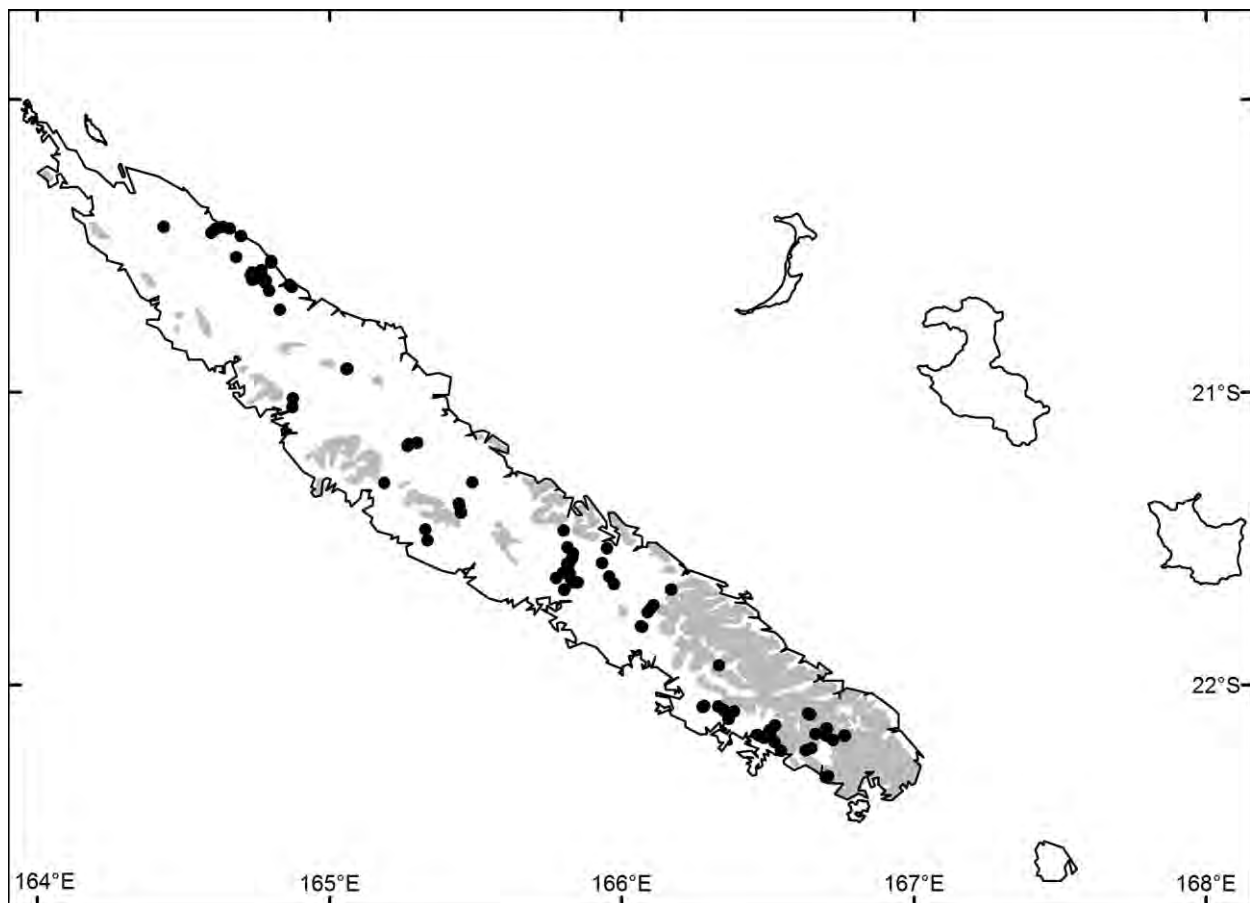


Figure 10. Records of *Eoargiolestes ochraceus*.

Trineuragrion percostale Ris, 1915

(Fig. 11)

Trineuragrion percostale Ris, 1915: 63.

Distribution (Fig. 12). This species has been recorded from both New Caledonia and Vanuatu (Lieftinck 1975; Tsuda 2000). In New Caledonia, we recorded it from more than 25 localities on Grande Terre.

Habitats. *Trineuragrion percostale* occurs in the same habitats as *C. uniserioides*, in small, fast-flowing, open or forested creeks. This species seems to avoid ultramafic soils.

biology and behaviour. Adults emerge in the morning, not far above the water in quiet parts of the stream along the banks. Adults remain around water. Males do not seem to be territorial and they fly above fast-flowing water.

Status. Common on Grande Terre and has also been reported for Vanuatu, we rank its conservation status as LC.

Family Coenagrionidae Kirby, 1890

Although this is the most diverse Zygopteran family on a world-scale, in New Caledonia, it is only represented by four genera and six species. The isolation of the archipelago may explain the low colonisation rate by this family. Resident species are of moderate size and prefer sunny and stagnant waters. Except for *Ischnura pamela* Vick & Davies, 1988, all species found on the archipelago also occur elsewhere in the Australasian region. Coenagrionidae adults remain close to water. Mating can last for several hours and eggs are inserted into plants. These small to tiny species with weak flight abilities reach new, sometimes distant, areas when they are taken by strong winds. Their generally eurytopic habitat requirements enable them to establish in many habitats, especially those with standing water.



Figure 11. *Trineuragrion percostale*, male.

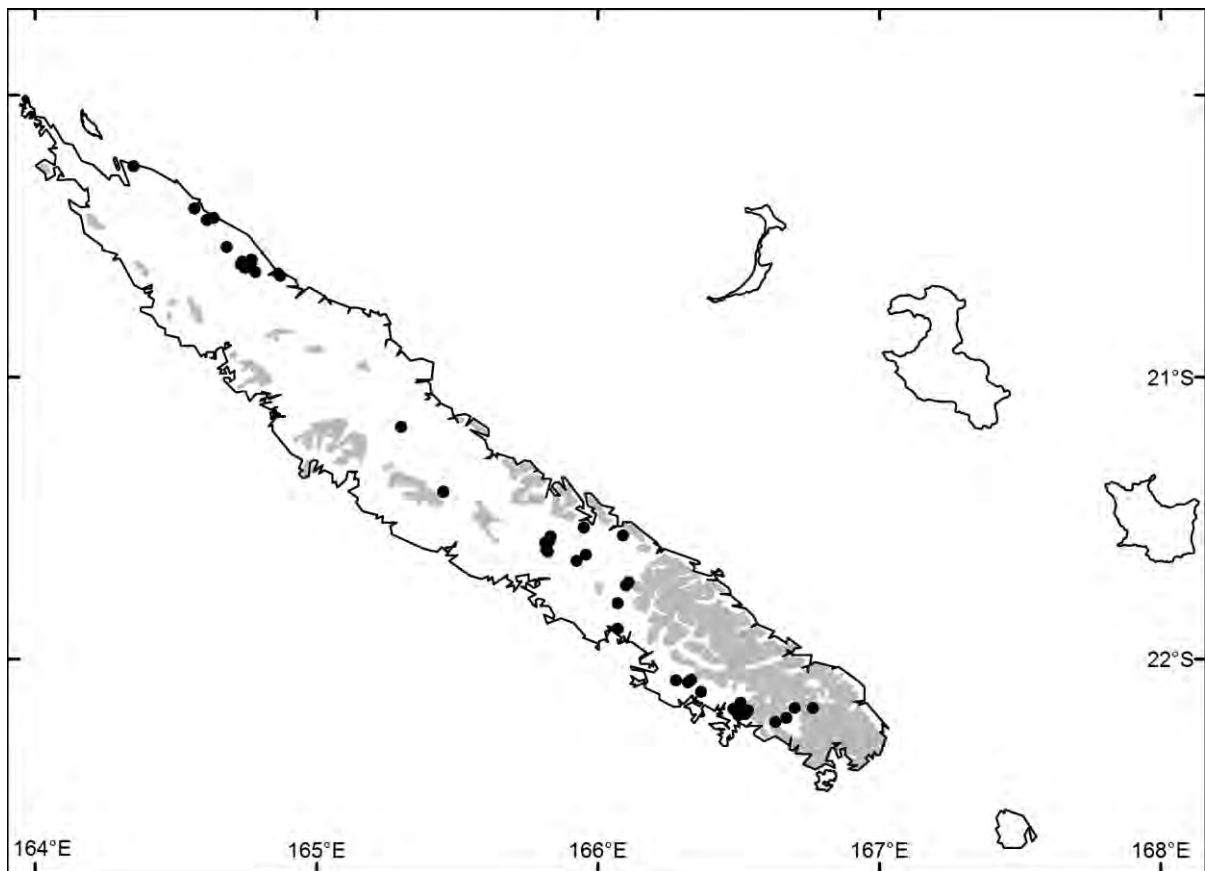


Figure 12. Records of *Trineuragrion percostale*.

Agriocnemis exsudans Selys-Longchamps, 1877

(Fig. 13)

Agriocnemis exsudans Selys-Longchamps, 1877: 148; *Agriocnemis vitiensis* Tillyard, 1924.



Figure 13. *Agriocnemis exsudans*: a) mature male, b) immature male, c) mature female, d) immature female.



Figure 13. (Continued)

Distribution (Fig. 14). This species is widely distributed in the South-west Pacific, including Fiji, western Samoa, American Samoa, Vanuatu and Norfolk (Tsuda 2000) as well as the Solomon Islands (Polhemus *et al.* 2008). In New Caledonia, it has been recorded from more than 70 localities. Bigot (1985) recorded two females on Ouvéa. One specimen collected on 15th January 1968 in the municipality of Sarraméa is held in the ONNC collection.

Habitat. *Agriocnemis exsudans* has a large ecological range. It frequently inhabits habitats with standing water and calm sectors of streams and rivers as well as water-filled drains. It occurs in cleared or thinned woodlands but avoids ultramafic soil and forest. Its habitats must have well-developed, dense, herbaceous bankside vegetation in which adults live.

biology and behaviour. Adults do not stray far from water and males appear territorial. Mating lasts for more than 40 minutes. Afterwards females lay eggs independently, but guarded by their mates that remain nearby. Egg laying begins with the female out of the water, where she inserts her eggs into tender plant parts immediately beneath the surface. As she works her way down the stem she goes under water until she is totally submerged. Emergence occurs all day long not far above the water and on any convenient perch.

Status. Because of the large regional and New Caledonian distribution, we rank *A. exsudans* as LC.

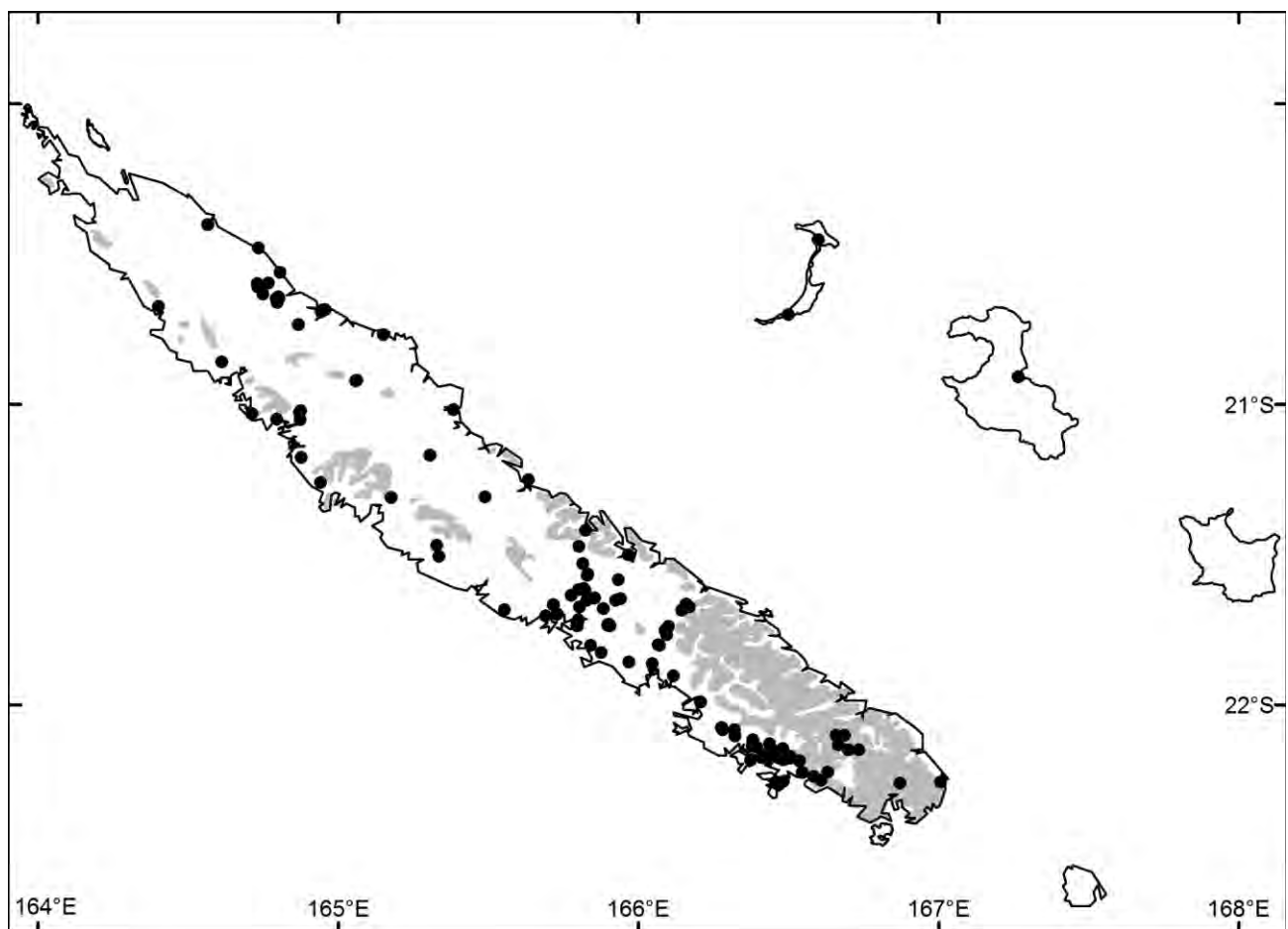


Figure 14. Records of *Agriocnemis exsudans*.

Austroagrion watsoni Lieftinck, 1982

(Fig. 15)

Austroagrion watsoni Lieftinck, 1982: 293.

Distribution (Fig. 16). It is a common and widespread species in Australia, but has a highly restricted distribution in New Caledonia, with only a few known localities in the south of Grande Terre. It was first reported by Bigot (1985) who collected the species in February 1980 on the banks of the Grand Lac (Plaine des Lacs). DG observed one specimen in February 2004 above a cattle tick-treatment pool in the Dumbéa River. It may be a recent establishment on the island or a species in decline in New Caledonia.

Habitat. *Austroagrion watsoni* is only recorded from open sunny habitats including standing to slowly running waters with dense herbaceous vegetation on the banks.



FIGURE 15. *Austroagrion watsoni*: a) male, Australia (E. Nielsen), b) female, Australia (R. Richter).

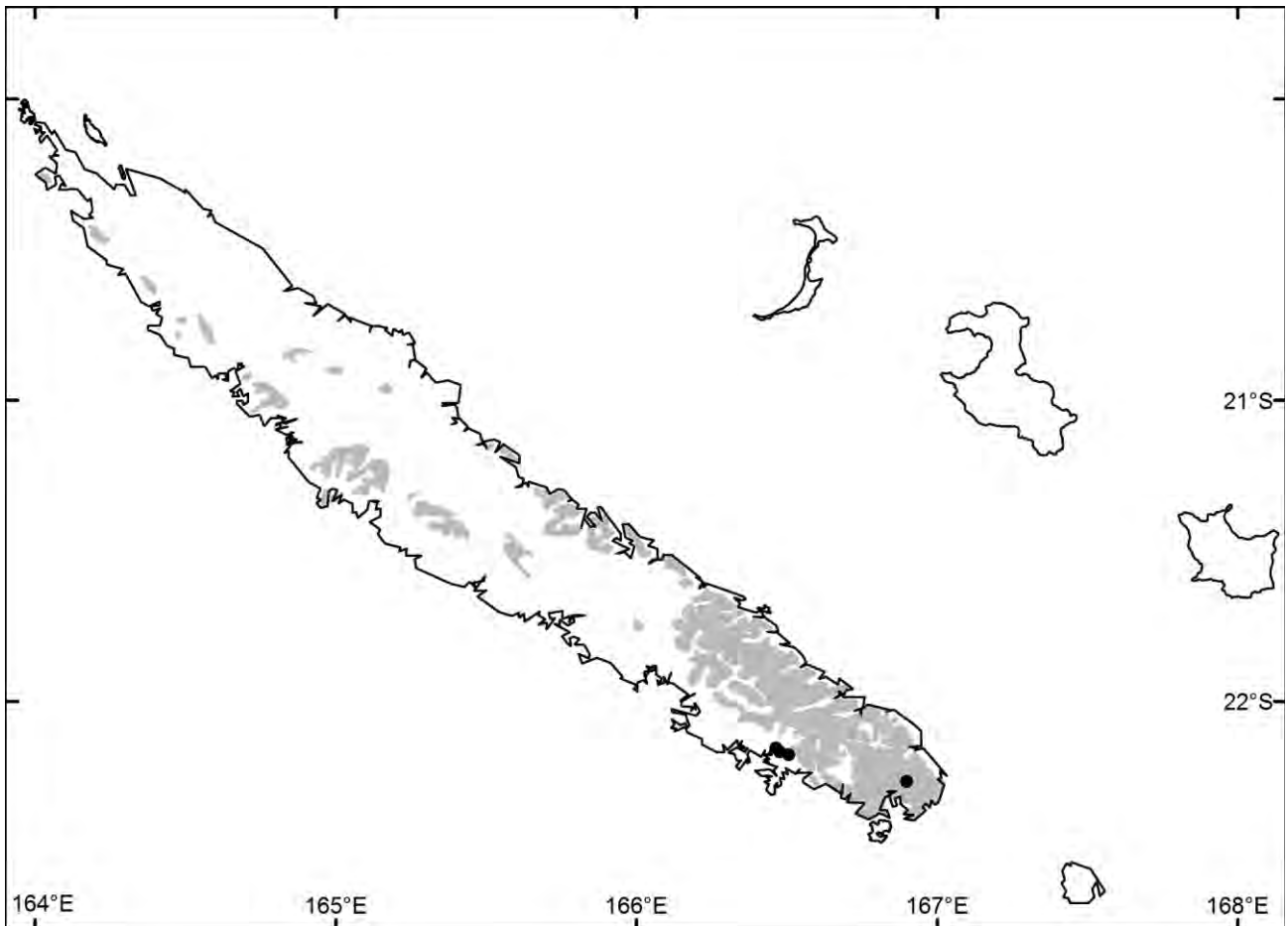


Figure 16. Records of *Austroagrion watsoni*.

biology and behaviour. The larva of this species was described (Hawking 1986; Theischinger & Hawking 2006) but its behaviour is still unknown.

Status. *Austroagrion watsoni* is one of the rarest species in New Caledonia, with very few specimens observed and it has not been seen since 2004. Therefore, we lack data to assess its conservation status in New Caledonia, as the species may be at the limit of its distribution or may be a vagrant. Lieftinck (1982) revised the genus *Austroagrion* Tillyard, 1913 and stated that specimens of *A. watsoni* from New Caledonia are darker than those from Australia. According to Davies (2002) it may be an introduced species (he called it an ‘illegal immigrant’).

***Ischnura aurora* brauer, 1865**

(Fig. 17)

Agrion (Ischnura) aurora Brauer, 1865a: 510; *Agrion delicatum* Brauer, 1858; *Ischnura orientalis* Selys-Longchamps, 1876; *Ischnura delicata* Selys-Longchamps, 1876; *Ischnura bhimtalensis* Sahní, 1965.

Distribution (Fig. 18). This species is widespread in the tropical and temperate zones. Dumont (2013) provided molecular evidence that established its current range to lie mainly between Wallace’s Line and the Society Islands (French Polynesia) in the east (Paulian 1998), including Australia and Tasmania (Theischinger & Hawking 2006) and New Zealand (Rowe 1987). On Grande Terre *I. aurora* has been recorded from 13 sites where it is rarely abundant. Bigot (1985) reports collecting two females in Nakutakoin (Dumbéa municipality), where we also found it in February 2011.

Habitat. *Ischnura aurora* is observed in sunlit areas with standing to very slowly running water, not very deep and with dense aquatic vegetation. These habitats can be swamps, pools and ponds but also wetlands along drains and other waterways. The species avoids ultramafic soils.



17a



17b

Figure 17. *Ischnura aurora*: a) male, b) female.

biology and behaviour. *Ischnura aurora* is opportunistic and migratory with a strong dispersion ability. Rowe (1987) gives some information on immature stages. Eggs measure from 0.75 to 0.78 mm long. In New Zealand, eggs

develop within two or three weeks and larvae in seven to eight weeks. Emergence occurs at midday, 2–3 cm above the water, larvae clasping herbaceous plants. Adults fly over calm water with dense aquatic plants reaching the surface. Males guard a tiny territory and pursue females that cross their territories. The mating wheel lasts almost an hour. The female lays its eggs in floating plants or in aquatic plants reaching the surface, but avoids immersion.

Status. Considering its global distribution, *I. aurora* is not threatened. However, in New Caledonia only small and scattered populations are recorded, so we consider it to be VU.

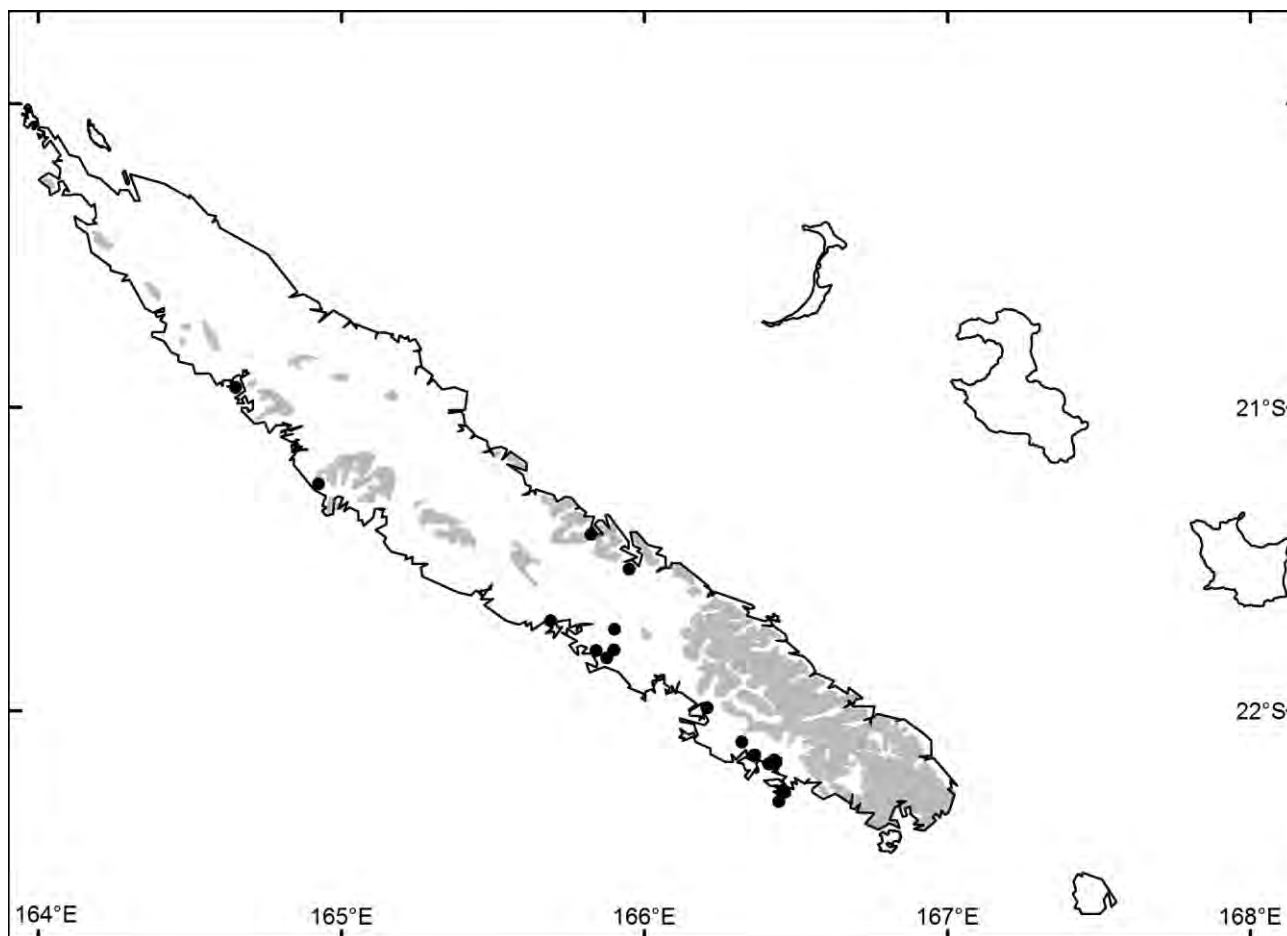


Figure 18. Records of *Ischnura aurora*.

***Ischnura heterosticta* (burmeister, 1839)**

(Fig. 19)

Agrion heterosticum Burmeister, 1839: 820; *Agrion distigma* Brauer, 1869.

Distribution (Fig. 20). This taxon is recorded from eastern Indonesia to Palau and Tonga, including all of mainland Australia and Tasmania. In New Caledonia, it has been recorded from more than 50 localities, including ultramafic substrates, on which it is abundant. Bigot (1985) recorded several individuals from Ouvéa. Several individuals from Anse Vata in Nouméa, Pont Pérignon (Parc Provincial de la Rivière Bleue) and Montagne des Sources (30/12/1963) are also held in the ONNC collection.

Habitat. *Ischnura heterosticta* and *A. exsudans* often occur syntopically.

biology and behaviour. The larva was described by Hawking (1986). Its behaviour is very similar to *I. aurora*. *Ischnura* Charpentier, 1840 species are highly aggressive, it is not uncommon to see *I. heterosticta* catching and eating individuals of *A. exsudans*.

Status. According to its wide regional distribution, including New Caledonia, we do not consider *I. heterosticta* as threatened and rank it as LC.



FIGURE 19. *Ischnura heterosticta*: a) male, b) female.

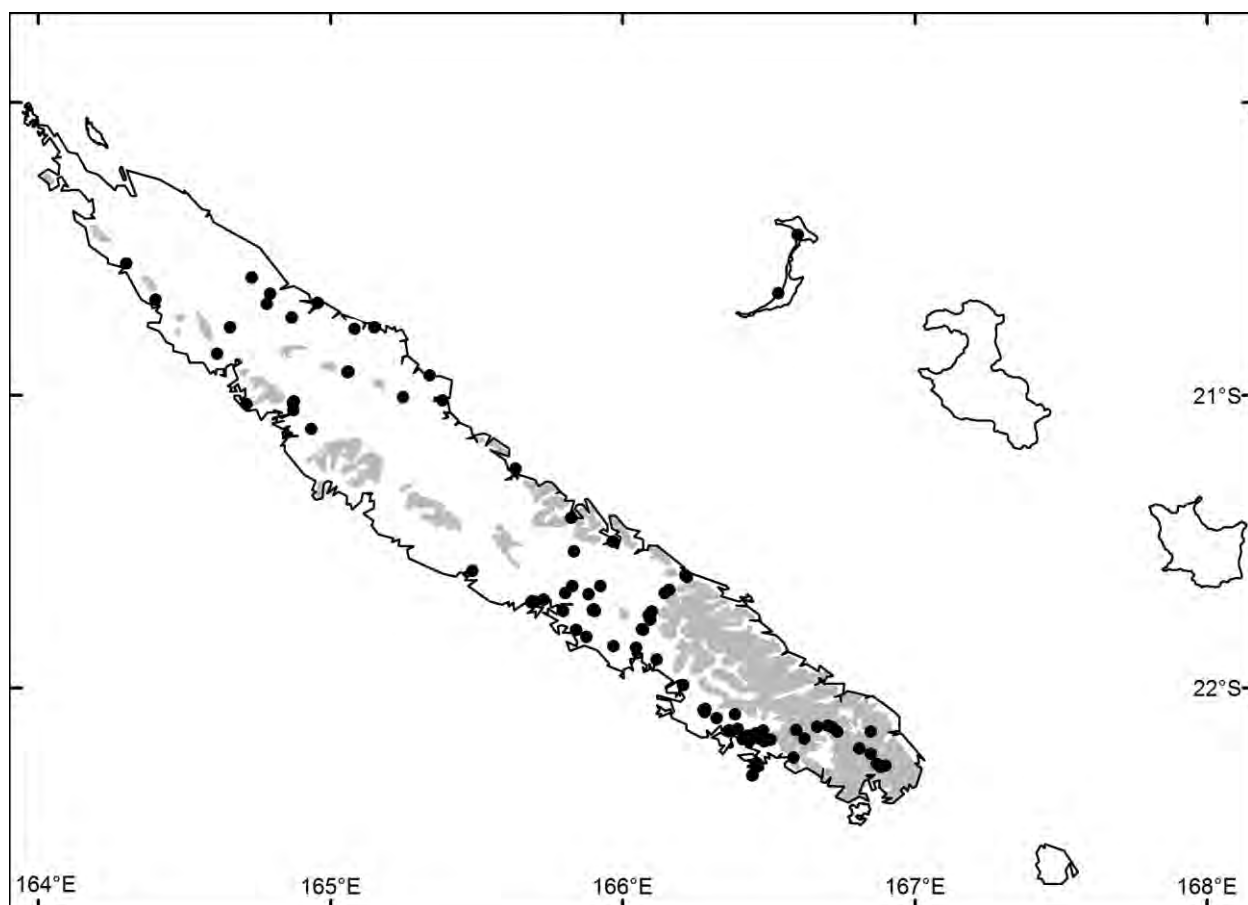


Figure 20. Records of *Ischnura heterosticta*.

***Ischnura pamelae* Vick & Davies, 1988**

(Fig. 21)

Ischnura pamelae Vick & Davies, 1988: 281.

Distribution (Fig. 22). Endemic to Grande Terre. This species is only known from the Plaine des Lacs, where eight localities have been recorded (northernmost record: swamps close to Lac Yaté). It has been observed in small populations.

Habitat. *Ischnura pamelae* is confined to sunny standing water habitats dominated by helophytes. These places can be swamps, ponds and pools on ultramafic soil.

biology and behaviour. Adults are encountered over water bodies, often sitting on emergent rushes (Juncaceae). Mating wheels are formed in the same places and last up to more than an hour, after which the female oviposits alone. The larval biology is unknown.

Status. *Ischnura pamelae* appears at risk considering its restricted range and its small populations. we rank it as EN.

***Xanthagrion erythroneurum* Selys-Longchamps, 1876**

(Fig. 23)

Xanthagrion erythroneurum Selys-Longchamps, 1876: 231.

Distribution (Fig. 24). This is a monotypic genus, with a widespread distribution, from Indonesia to most of Australia and Fiji (Tsuda 2000). In New Caledonia, it has been recorded from five localities only in the south of Grande

Terre. One specimen was collected in Nouméa (Kimmins 1953) and another in the Montagne des Sources, both are in the ONNC collection. Davies (2002) reported to have observed this species all over the island in 1979, 1981, 1983 and 1984, but did not give the localities where he observed it.



Figure 21. *Ischnura pamela*, mating pair.

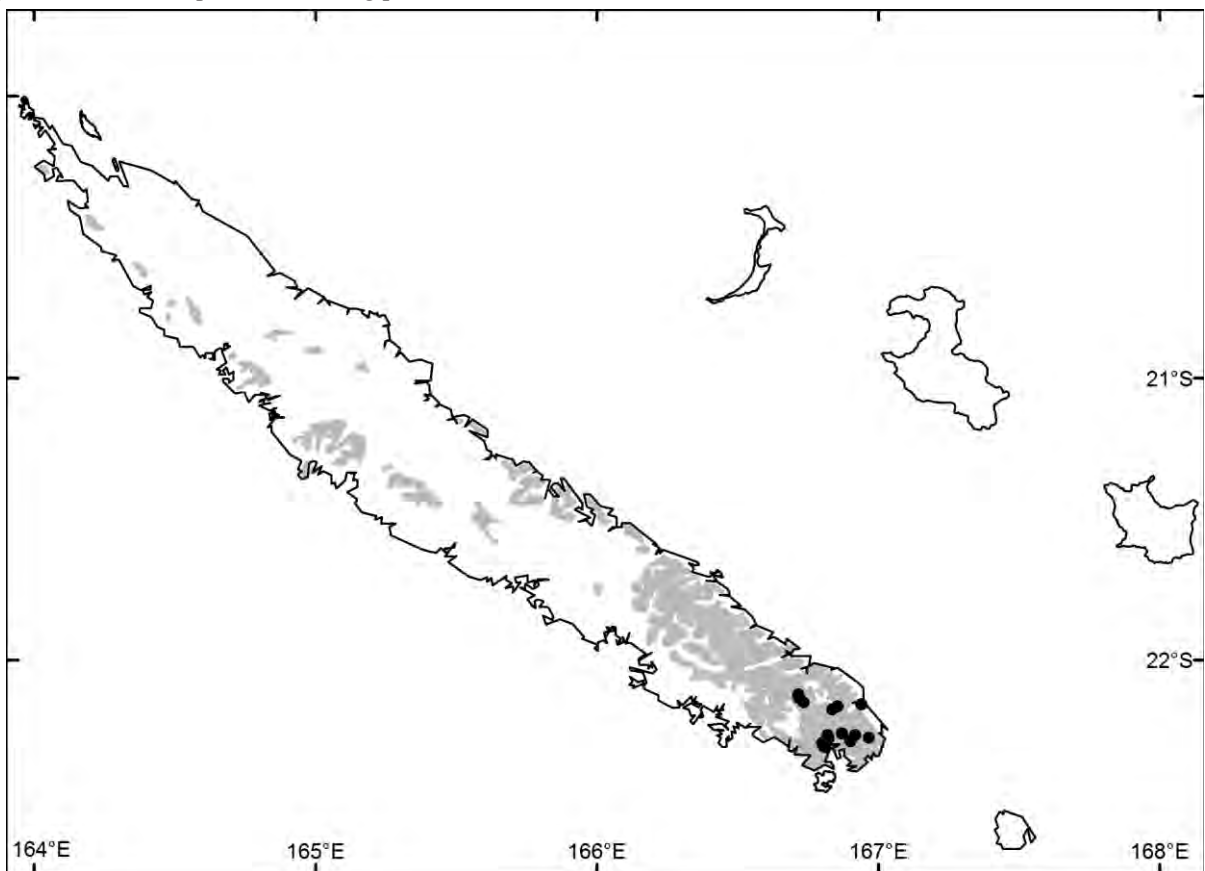


Figure 22. Records of *Ischnura pamela*.



23a



23b

FIGURE 23. *Xanthagrion erythroneurum*: a) male, b) female.

Habitat. *Xanthagrion erythroneurum* occurs in standing water or sunny places with slow currents. Typical habitats are pools and streams with dense herbaceous vegetation on their banks.

biology and behaviour. The larva was partially described (Hawking 1986; Theischinger & Hawking 2006). Males rest on twigs above the water and mating occurs in river-bank vegetation.

Status. According to Davies (2002), its distribution in New Caledonia is probably more extensive than currently known. *Xanthagrion erythroneurum* should be considered as insufficiently documented but probably locally threatened. As a precaution, we provisionally rank it as VU within the archipelago.

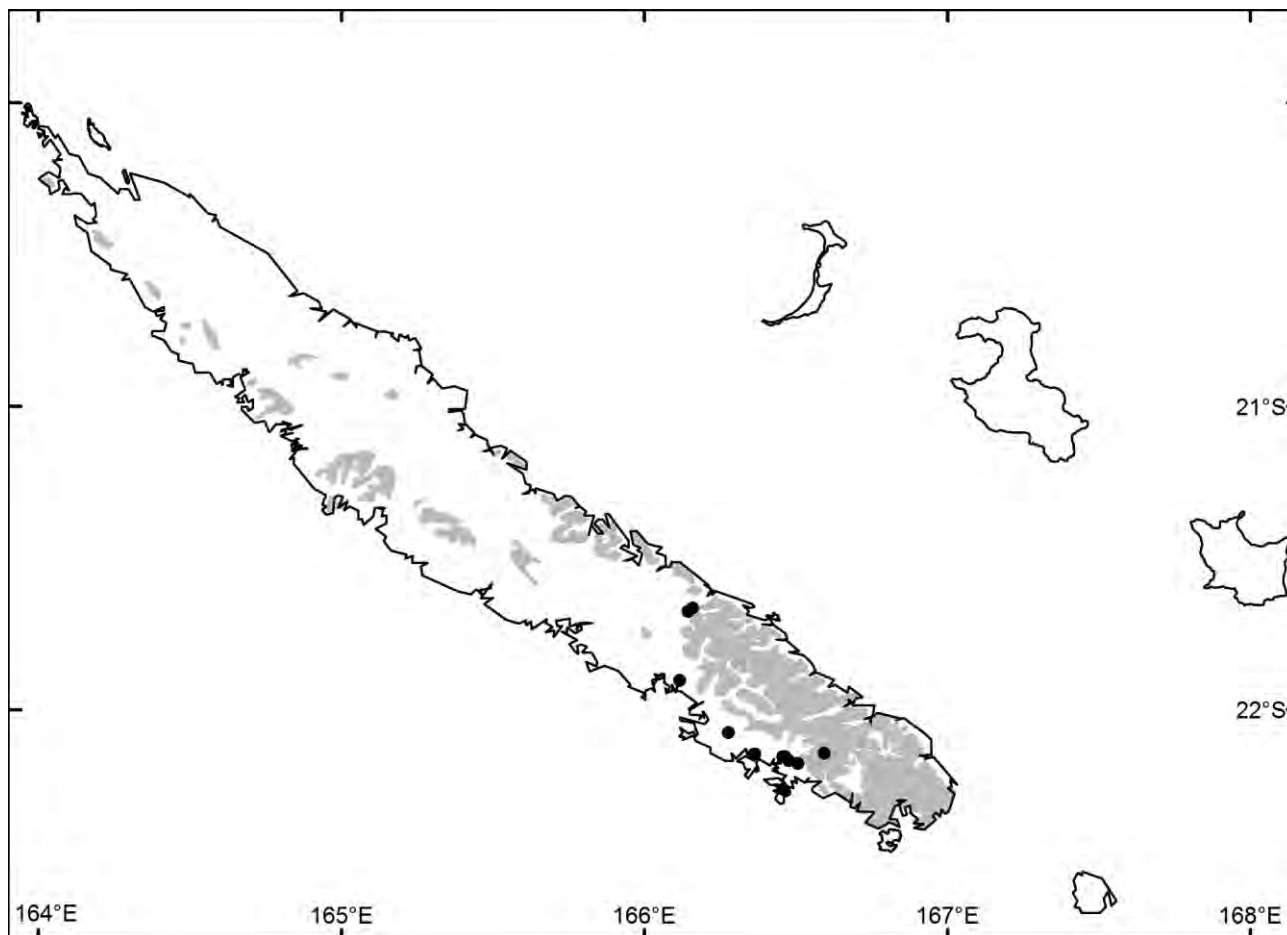


Figure 24. Records of *Xanthagrion erythroneurum*.

Family Isostictidae Fraser, 1955

This small family of 12 genera is recorded from Australasia (including Indonesia, Solomon Islands and New Caledonia, where the genus *Isosticta* comprises five endemic species). Isostictidae are easily distinguished from other New Caledonian Zygoptera by their very slender build, narrow wings and long and slender abdomen. The identification of the five species present is difficult and requires examination of several wing characters as well as details of the male abdominal appendages and the female pronotum. The adults remain near the forest creeks and streams, in which their larvae develop. Accompanied by males (tandem), females lay eggs in vegetation over and along the water. Their biology is unknown. As with other running water species, New Caledonian *Isosticta* are very sensitive to water pollution, deforestation and fires. It would be desirable to survey natural running freshwater habitats in the Nouméa area, where the water quality is constantly getting worse.

Isosticta gracilior Liefertinck, 1975

(Fig. 25)

Isosticta gracilior Liefertinck, 1975: 148.



Figure 25. *Isosticta gracilior*, ovipositing pair.

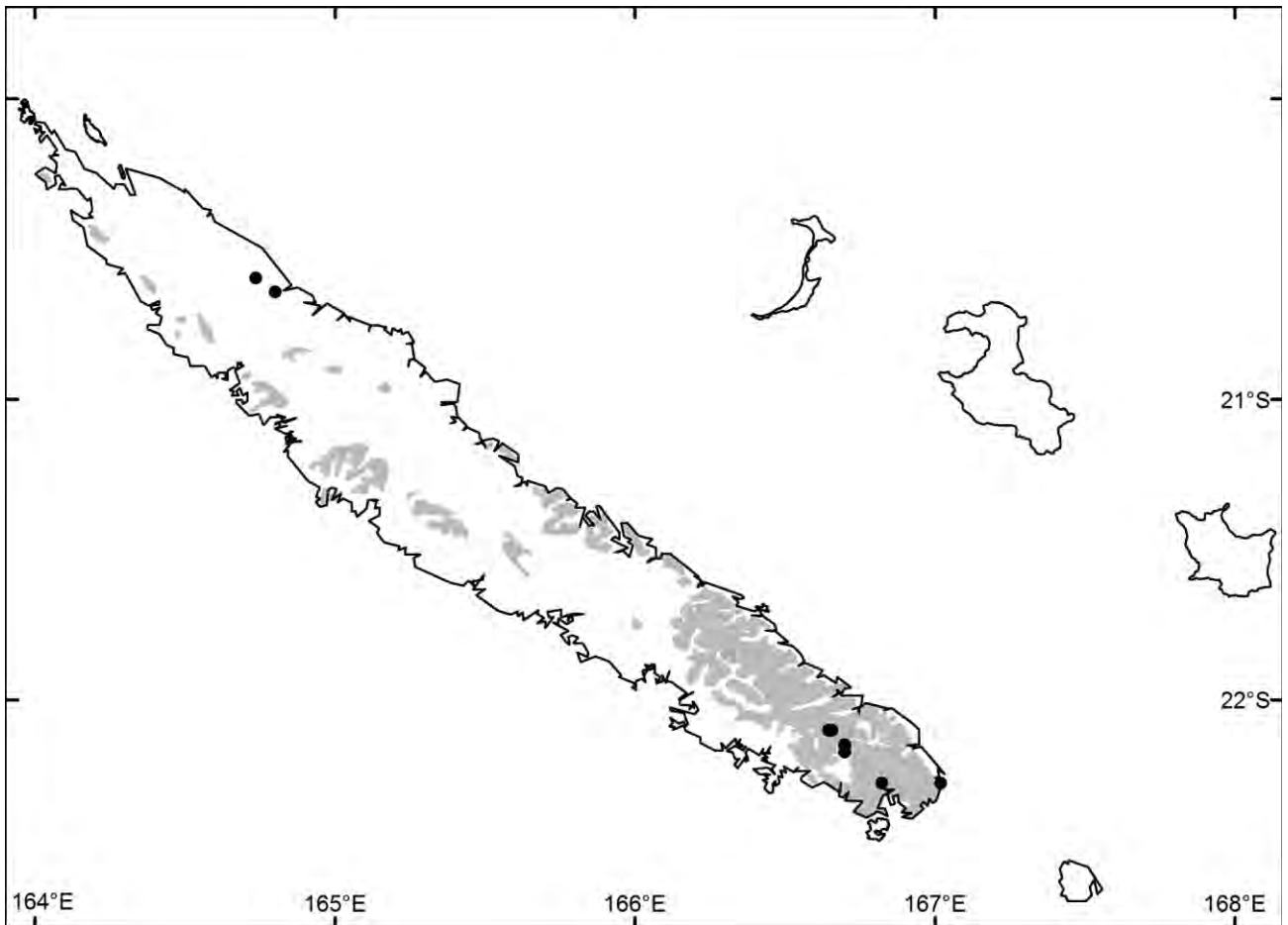


Figure 26. Records of *Isosticta gracilior*.

Distribution (Fig. 26). Endemic to Grande Terre. This rare species is only known from six localities, all at low altitude. It has been recorded in low numbers at the sampling sites.

Habitat. The species occurs along rivers and streams flowing in forested plains or in hilly country on ultramafic soils.

biology and behaviour. Adult stay close to the water and mating occurs at the edge of waterways. The biology of this species is unknown.

Status. The distribution of *I. gracilior* seems patchy but this may reflect a lack of observations. Because populations are rare and dispersed, we rank *I. gracilior* as EN.

***Isosticta humilior* Liefstinck, 1975**

(Fig. 27)

Isosticta humilior Liefstinck, 1975: 149.



Figure 27. *Isosticta humilior*, male.

Distribution (Fig. 28). Endemic to Grande Terre. It is known from seven localities, most of which are in the Province Sud. Populations are always small.

Habitat. *Isosticta humilior* occurs along creeks in hilly forest habitats. It avoids ultramafic environments.

biology and behaviour. The larva and habits of this species are unknown.

Status. *Isosticta humilior* is very rare and usually only a few individuals are observed. For these reasons we rank it as EN.

***Isosticta robustior* Ris, 1915**

(Fig. 29)

Isosticta robustior Ris, 1915: 66.

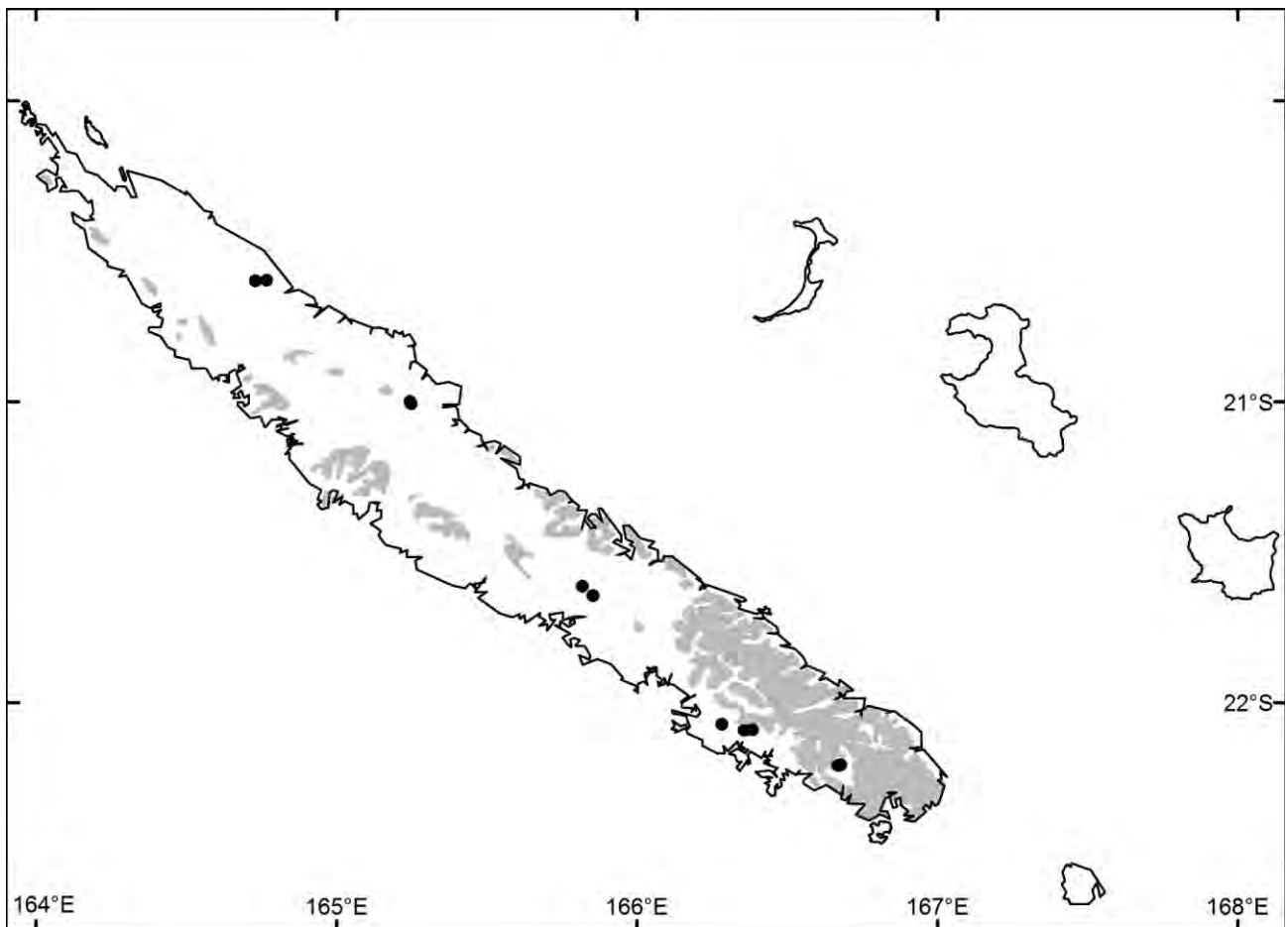


Figure 28. Records of *Isosticta humilior*.

Distribution (Fig. 30). Endemic to New Caledonia. This large species is recorded from more than 40 localities in the mountains of Grande Terre. Kimmins (1958) recorded it from Lifou but this island has no rivers so individuals must have dispersed from Grande Terre.

Habitat. This species occurs on creeks with rocky beds in hilly forest environments. It seems to avoid ultramafic soils, especially in the lowlands.

biology and behaviour. Larvae were described by Lieftinck (1976). Adults remain around water, resting for long times on riverside vegetation. Oviposition takes place in tandem, the female inserting her eggs into diverse water plants as well as decomposing timber. Sometimes, eggs are laid 2 or 3 m above the water surface. DG observed a complete emergence on 14th January 2010 above the creek on the road of “Le Sanatorium” on the east side of the Col de la Pirogue near Païta, between 07:15 h (larva coming to rest) and 11:45 h (first flight of the imago).

Status. *Isosticta robustior* is widespread on Grande Terre, with sometimes substantial populations, hence we rank it LC.

***Isosticta spinipes* Selys-Longchamps, 1885**

(Fig. 31)

Isosticta spinipes Selys-Longchamps, 1885: 7.

Distribution (Fig. 32). Endemic to New Caledonia. According to Davies (2002), this species is widely distributed on Grande Terre with more than 15 sites recorded. There are spread in three sectors: on mountains in the east of Nouméa, at Col d’Amieu and in the north at the foot of the Mont Panié range. Strangely, the type locality of the male holotype is Lifou Island. One specimen collected at Col d’Amieu in November 1998 is held in the CXMNC collection.



FIGURE 29. *Isosticta robustior*: a) male, b) female.

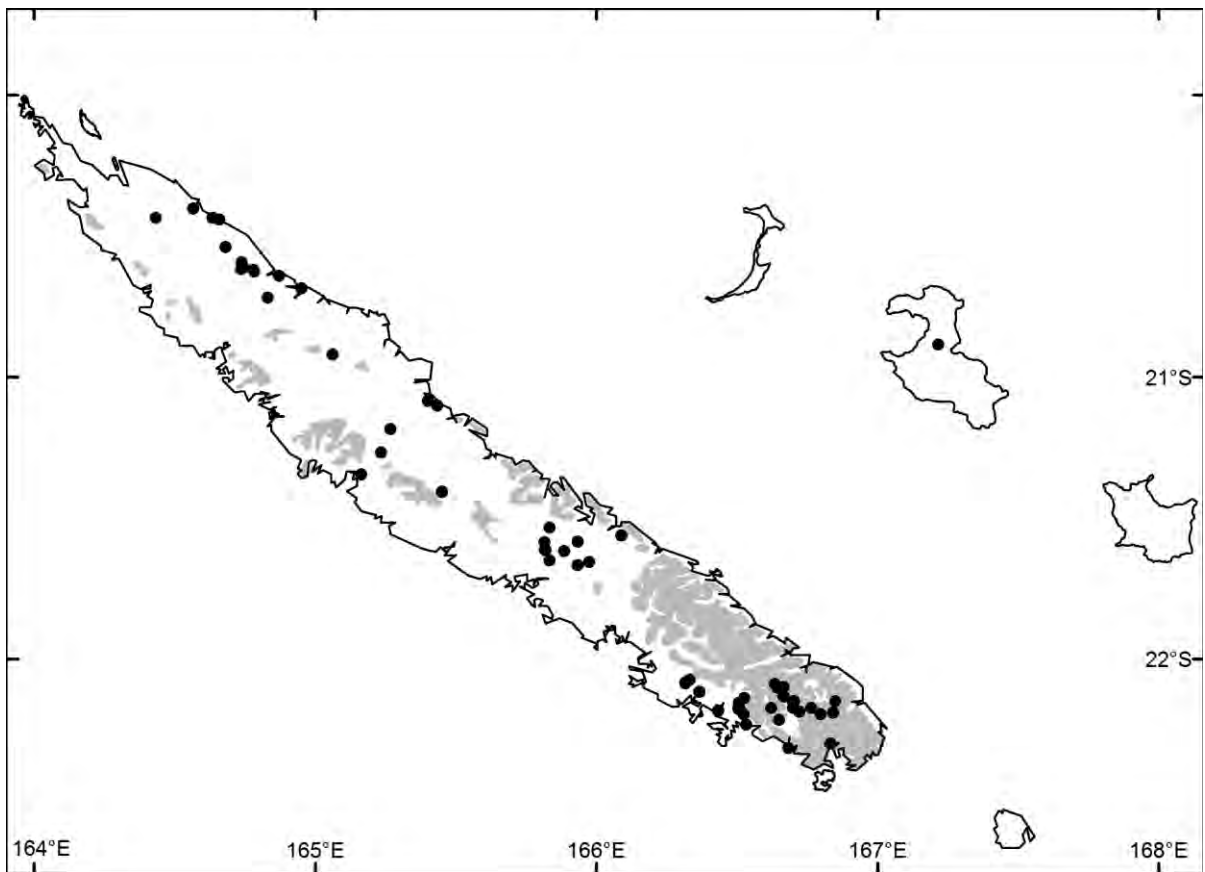


Figure 30. Records of *Isosticta robustior*.



Figure 31. *Isosticta spinipes*, male (M. Marinov).

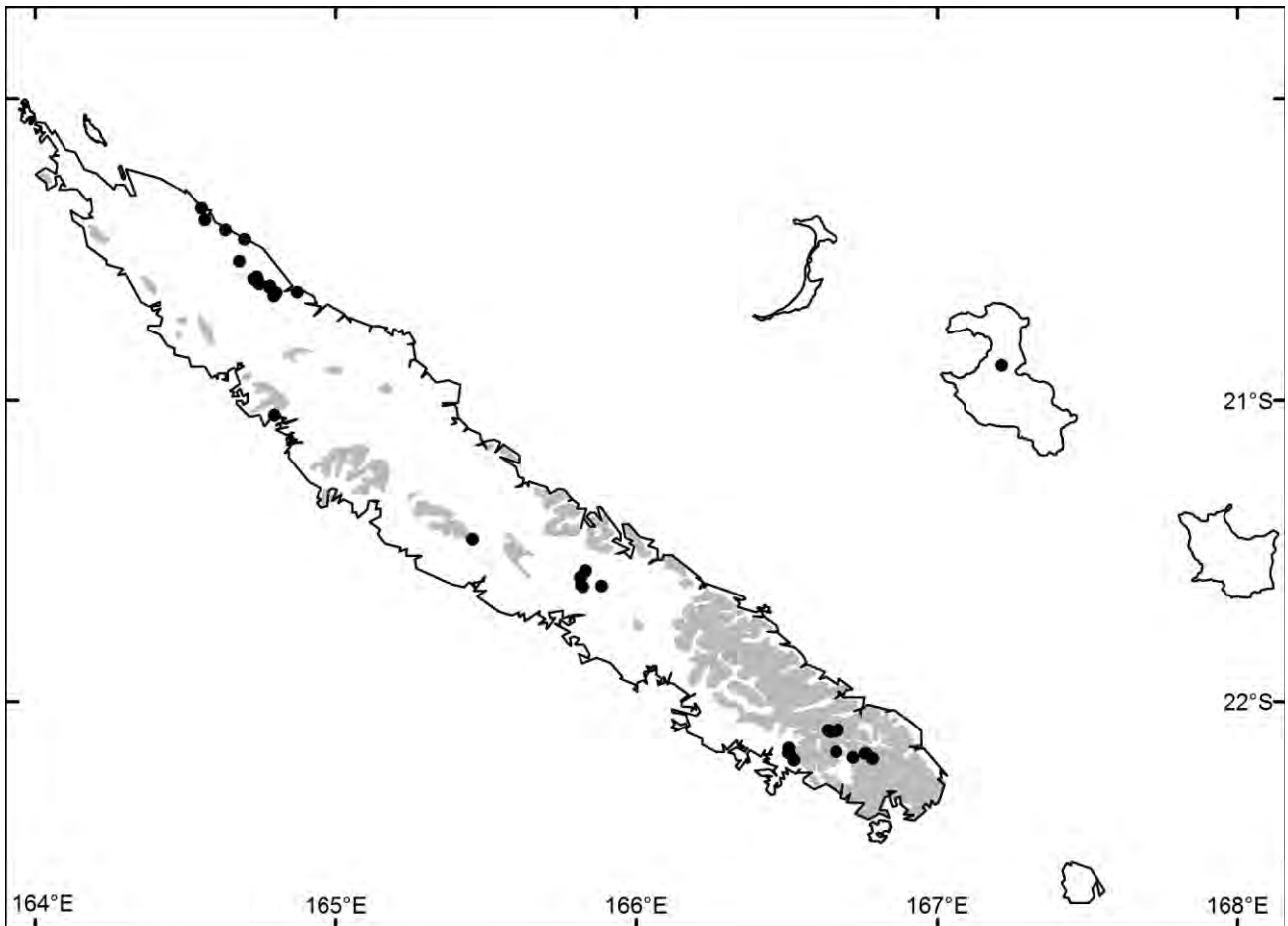


Figure 32. Records of *Isosticta spinipes*.

Habitat. Small creeks in hill forest, but can also be present at lower altitudes. This species seems to tolerate ultramafic soils in the south of Grande Terre.

biology and behaviour. Its larva was described by Lieftinck (1976). Adults are always found on stream banks, usually as single individuals. The biology of this species needs further study.

Status. This species is less abundant, often and easily overlooked within larger populations of other *Isosticta* species. The species is probably more common than observed in the three sectors of its main occurrence. As a precaution, we rank *I. spinipes* as VU.

***Isosticta tillyardi* Champion, 1921**

(Fig. 33)

Isosticta tillyardi Champion, 1921: 38.

Distribution (Fig. 34). Endemic to New Caledonia. This species is wide spread on Grande Terre with nearly 50 known localities. It also occurs on Île des Pins (Bigot 1985). Several specimens collected in February 2006 in the Parc des Grandes Fougères (near La Foa) are held in the CXMNC collection.

Habitat. Similar to habitats in which *I. robustior* occurs, but *I. tillyardi* is also present in slow-flowing lowland streams. This species seems to cope with ultramafic soils in the south of Grande Terre.

biology and behaviour. Adult males move along waterways, searching for females. Oviposition is in diverse plants overlaying the water, but also in rocky crevices. The larva was described by Lieftinck (1976). Emergence occurs in the morning, not far above the water, on rocks or emergent vegetation.

Status. *Isosticta tillyardi* is largely distributed over Grande Terre with often large populations. we rank it as LC.



Figure 33. *Isosticta tillyardi*: a) male, b) female.

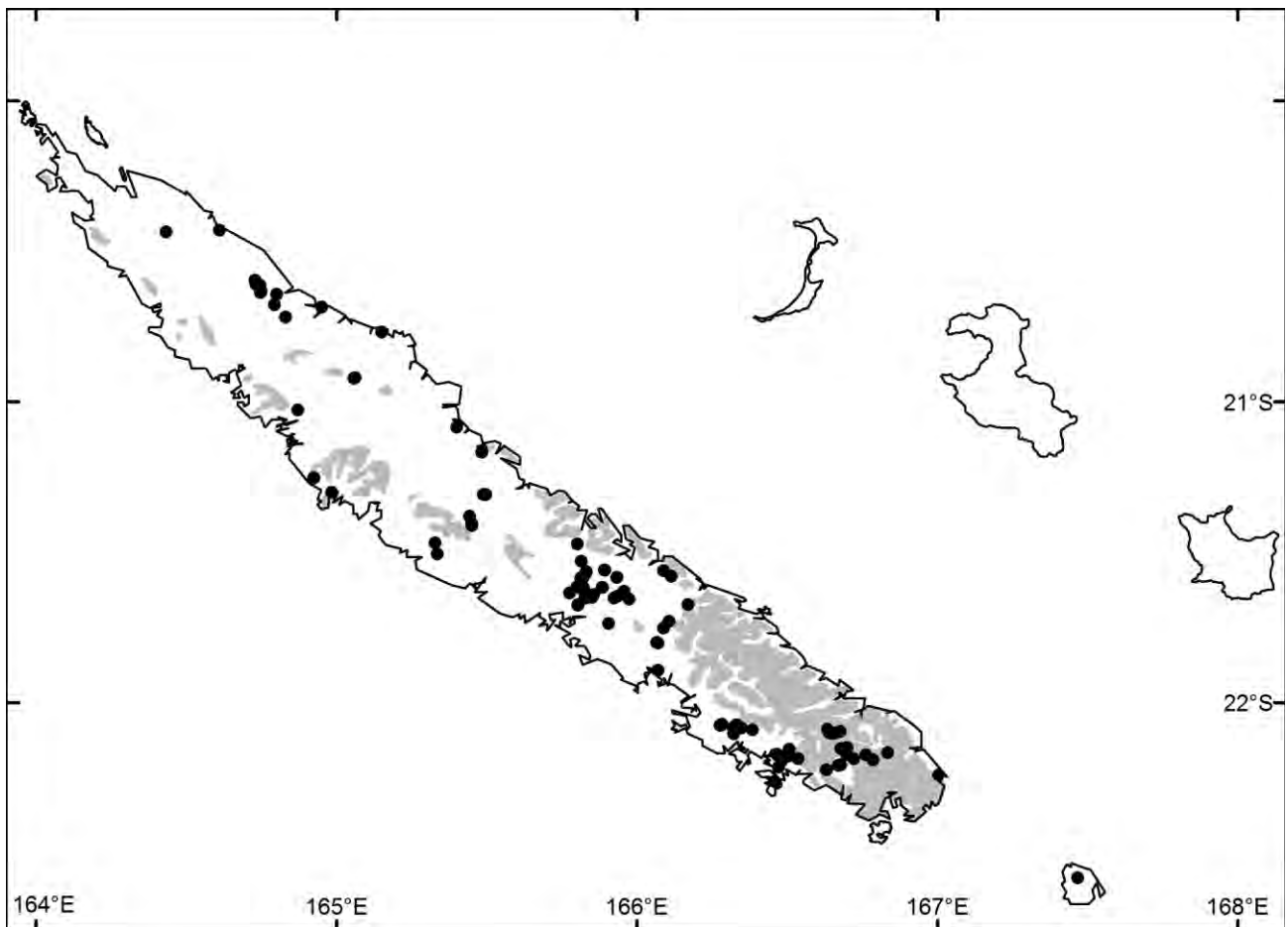


Figure 34. Records of *Isosticta tillyardi*.

Family Lestidae Calvert, 1901

This worldwide family is represented in New Caledonia by only two species. All Lestidae lay their eggs on either submerged or emergent parts of plants or twigs overhanging the water surface. The development and hatching of eggs in emerged parts of plants can be delayed for several weeks or months (which is known from temperate regions).

Taxonomic note: Both genera represented in New Caledonia can be distinguished by the size of the discoidal cells on fore and hind wings. They are similar in *Lestes* Leach, 1815, whereas in *Indolestes* Fraser, 1922, the hind wing cell is at least 1.5 times longer than its forewing cell.

Indolestes cheesmanae (Kimmins, 1936)

(Fig. 35)

Austrolestes cheesmanae Kimmins, 1936: 69.

Distribution (Fig. 36). This species has been recorded from both Vanuatu (Kimmins 1936; Lieftinck 1975; Tsuda 2000) and New Caledonia on Grande Terre, with nine known localities from north to south. It has rarely been collected, but we think it has been overlooked due to its cryptic lifestyle and insufficient sampling effort during its flight period. One specimen (unknown locality) is in the ONNC collection.

Habitats. The species prefers ponds, grassy marshes, and streams on slopes in forested areas. Ponds are mostly shallow, and may partially dry out seasonally. It has similar habitat preferences to *Lestes concinnus*.



Figure 35. *Indolestes cheesmanae*, male.

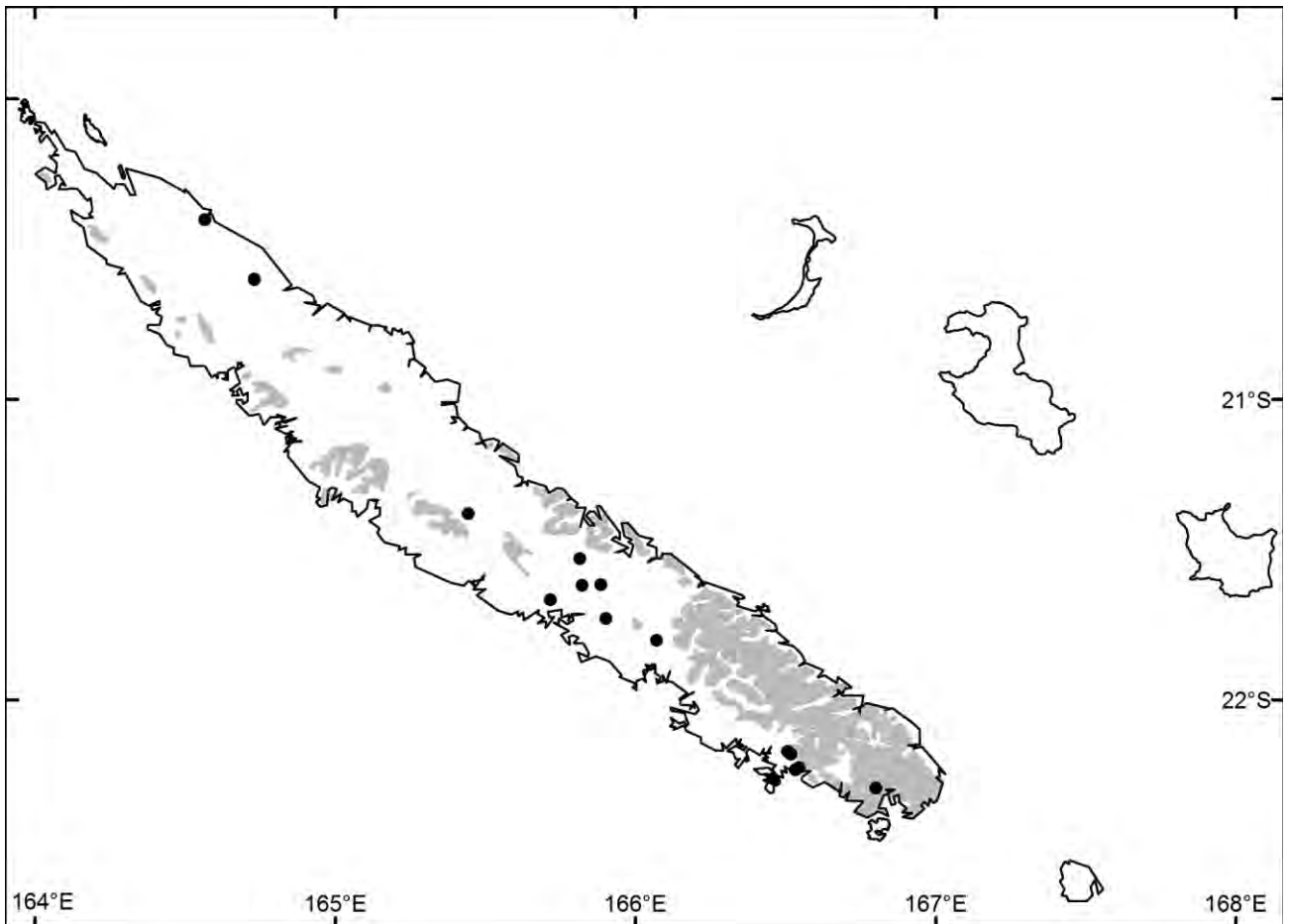


Figure 36. Records of *Indolestes cheesmanae*.

biology and behaviour. Its larvae are unknown but Lieftinck (1960) considered that they should be very similar to *Lestes concinnus* Hagen in Selys-Longchamps, 1862.

Status. *Indolestes cheesmanae* is a regional endemic from both Vanuatu and New Caledonia. Its preferred habitats are vanishing following disappearance of coastal marshes (especially in Nouméa and its surroundings) and drainage of other marshy areas. we consider this species as vulnerable (VU).

***Lestes concinnus* Hagen in Selys-Longchamps, 1862**

(Fig. 37)

Lestes concinna Hagen in Selys-Longchamps, 1862: 321; *Lestes amata* Hagen in Selys-Longchamps, 1862; *Lestes paludosus* Tillyard, 1906; *Lestes nympa* (nec Stephen) Selys-Longchamps, 1840; *Lestes forcipula* (nec Charpentier) Rambur, 1842; *Lestes uncatatus* Kirby, 1890.

Distribution (Fig. 38). This species is widely distributed from India to China and Taiwan to northern Australia (Tsuda 2000). In New Caledonia, it has been recorded at 11 localities across Grande Terre, mostly from the Province Sud. One specimen has been recorded from Montagne des Sources in 1963 (ONNC collection).

Habitats. As with most Lestidae, *L. concinnus* prefers flooded grassland, marshes and ponds with helophytes (such as Cyperaceae). These shallow and marshy waters are subject to annual periodic droughts.

biology and behaviour. The larva was illustrated in Theischinger & Hawking (2006). In New Caledonia, adults have been recorded in small populations in sunny and marshy areas. Adults are weak flyers and rest most of the time on vegetation, hence they are often overlooked.

Status. Considering its range in the Oriental and Australasian biogeographical areas, *L. concinnus* appears to be not threatened on a global scale, but in New Caledonia, the extensive destruction of coastal marshes (especially around Nouméa) and drainage of other marshy areas lead us to consider this species as Vulnerable (VU).

ANISOPTERA

Family Aeshnidae Rambur, 1842

This large family has an almost worldwide distribution (except Antarctica, Iceland and Greenland). In New Caledonia, six genera and eight species occur. They are large dragonflies with powerful flight capabilities that allow them to cross long distances, even over the ocean. Mating varies according to species, but is always rather prolonged, usually taking place under a hanging branch. with some exceptions, females lay their eggs unaccompanied by inserting them into plant tissues, rarely into moist soil.

***Aeshna (Adversaeschna) brevistyla caledonica* Davies, 2002**

(Fig. 39)

Aeshna brevistyla Rambur, 1842; *Aeshna lineata* Tillyard, 1916; *Aeshna oblita* Tillyard, 1916; *Adversaeschna brevistyla caledonica* Davies, 2002: 231.

The nomenclature of *Aeshna brevistyla caledonica* requires some consideration. The species is predominantly reported in the contemporary literature under the genus *Adversaeschna*. This name was proposed by watson (1992) who analysed the species' affinities and suggested a subgeneric status within *Aeshna*. The name was subsequently given a full generic status without further justification and is used to denote not only the New Caledonian populations of *A. brevistyla* (probably due to Davies (2002) who used it for the first time), but also Australian ones. Given the lack of published evidence to justify the elevation of this name to genus rank, we treat *Adversaeschna* as a subgenus, as proposed by watson (1992) for *Aeshna brevistyla* (Table 1).

Distribution (Fig. 40). A New Caledonian endemic subspecies, belonging to a monotypic subgenus that occurs elsewhere in Australia, New Zealand, Norfolk Islands, Raul Island in the Kermadec Archipelago, and Vanuatu

(Lieftinck 1975). The subspecies *A. brevistyla caledonica* is recorded from more than 20 localities in the Province Sud, with important populations in the Plaine des Lacs. One specimen collected at Anse Vata in Nouméa is in the ONNC collection.



Figure 37. *Lestes concinnus*: a) male, b) female.

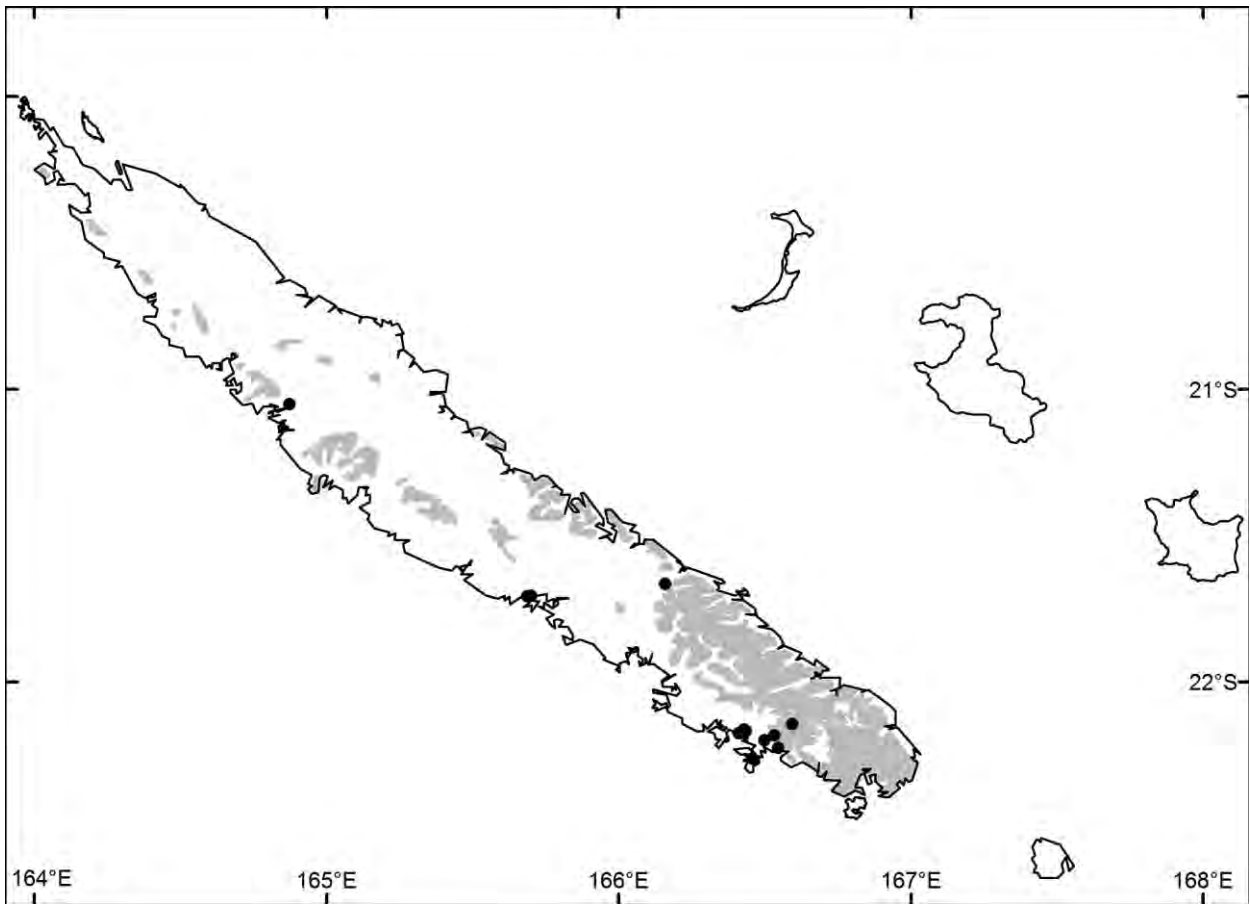


Figure 38. Records of *Lestes concinnus*.



Figure 39. *Aeshna brevistyla caledonica*, male.

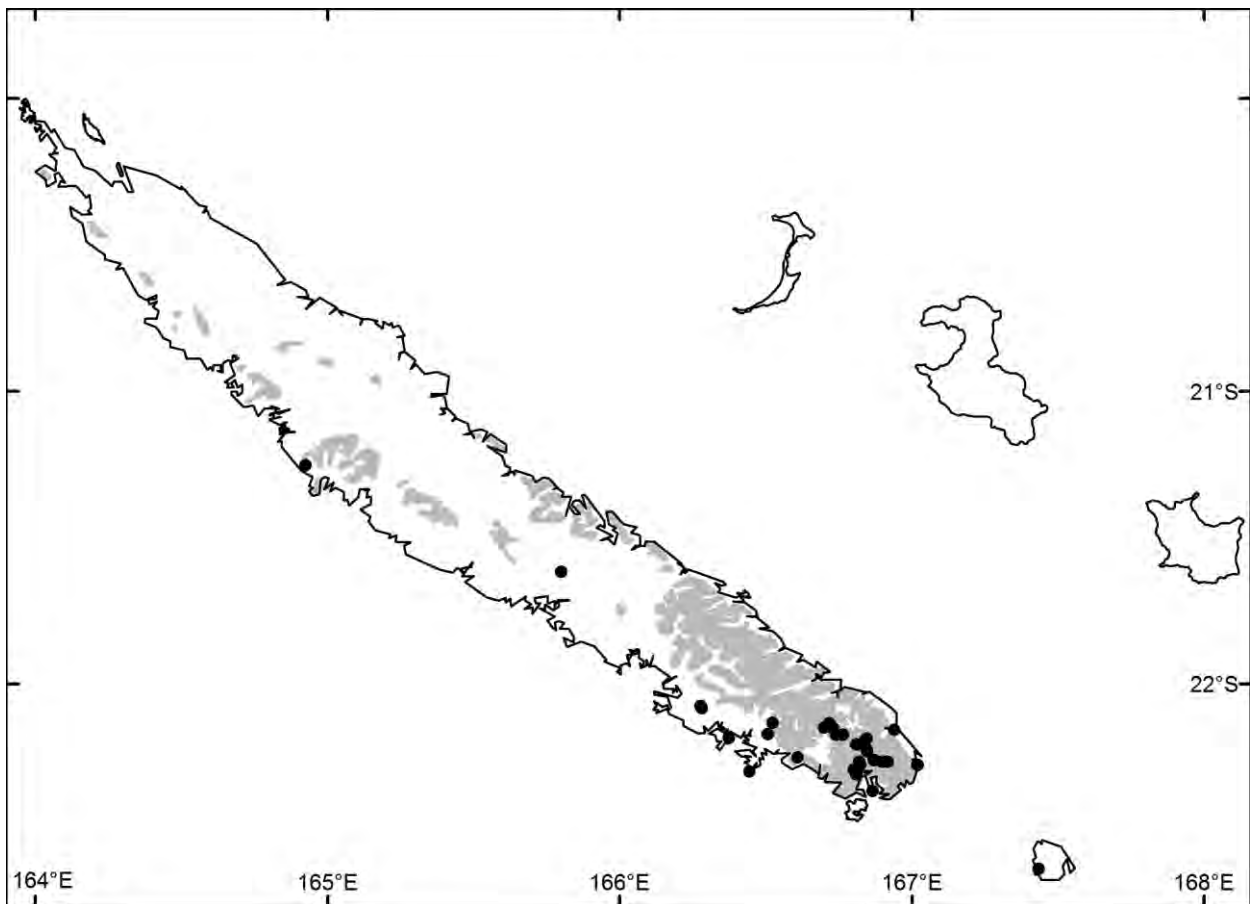


Figure 40. Records of *Aeshna brevistyla caledonica*.

Habitat. This species reproduces in sunlit standing waters, including swamps, ponds, lakes and sometimes still parts of streams and rivers in open areas. Typical habitats support sparse reed growth. This subspecies seems to prefer ultramafic areas.

biology and behaviour. Its larva was described by Lieftinck (1976). According to Rowe (1987), in New Zealand, eggs are between 1.3 and 1.5 mm long and the last larval stadium often emerges at night. The larvae climb to a height of 20–30 cm where adult emergence takes place. About three and a half hours later, the dragonfly flies off. In the Plaine des Lacs, exuviae were found on reeds, on low shrubs emerging from the water or high herbaceous clumps on banks. Males are territorial and tirelessly patrol the same path above the water while waiting for the arrival of a female. After mating, females lay their eggs alone in rushes and reeds emerging from the water.

Status. *Aeshna brevistyla caledonica* is only known from New Caledonia where it appears restricted to the Province Sud, but with large populations. we consider this species not at risk in the short term (NT).

Anaciaeschna jaspidea burmeister, 1839

(Fig. 41)

Aeschna jaspidea Burmeister, 1839: 840; *Protoaeschna pseudochiri* Foerster, 1908; *Aeschna tahitensis* Brauer, 1865.

Distribution (Fig. 42). This species is recorded from the Oriental Region (India to Japan) as well as northern Australia, New Guinea and most Pacific Islands, including French Polynesia (Paulian 1998; Tsuda 2000). we found this species only at a pond in Kouaoua, but Davies (2002) and winstanley & Davies (1983) observed it elsewhere. Some specimens collected in Nouméa are in the ONNC collection and a pair, collected in 2002 at the pond of the Agronomic Research Station in Pocquereux (La Foa municipality) is held in the CXMNC collection.

Habitat. It reproduces in stading waters such as permanent pools, ponds and lakes, but also in slowly running water (Theischinger & Hawking 2006).



Figure 41. *Anaciaeschna jaspidea*, male (J. Theuerkauf).

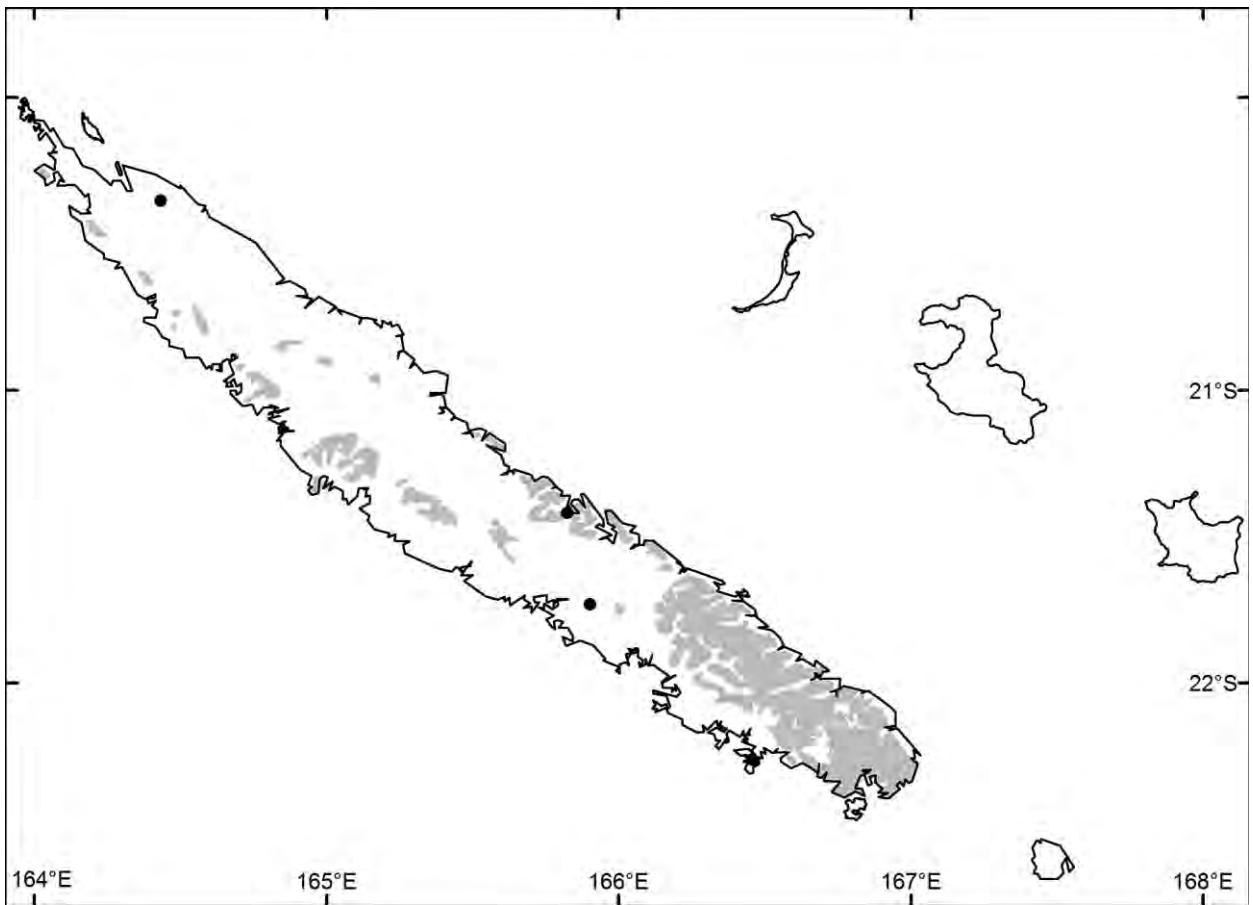


Figure 42. Records of *Anaciaeschna jaspidea*.

biology and behaviour. This migratory and crepuscular species is very difficult to observe and it is almost always encountered incidentally. Its biology is poorly documented.

Status. *Anaciaeschna jaspidea* appears sporadically in New Caledonia. Lacking recent information on its indigenous status, we assign it to the status DD.

Anax gibbosulus Rambur, 1842

(Fig. 43)

Aeschna gibbosulus Rambur, 1842: 187; *Anax fumosus* Hagen, 1867.



FIGURE 43. *Anax gibbosulus*, male.

Distribution (Fig. 44). This species is known from the north of India to the north of Australia and from several islands of the south-west Pacific to the Samoa Islands (Tsuda 2000) and Tahiti (Paulian 1998). In New Caledonia, it was reported from the Thy Forest by Lieftinck (1975) and we observed it in the north of the Mont Panié massif. Davies (2002) called it the most abundant species of Anactini of the island, but he did not indicate any locality. Davies may have confused it with *A. guttatus* (Burmeister, 1839). Because of their powerful flight and their nervousness, *Anax gibbosulus* and *A. guttatus* are difficult to capture and it is impossible to distinguish them in flight. In addition to the observations already known and those we validated, we encountered individuals of *Anax* at over a dozen additional locations, which we could not assign to either of these two species. To take into account these observations, we provide a joint distribution map which includes both species, each represented by a different icon, as well as a separate icon for observations identified only at the genus level.

Habitat. The species frequents standing water including brackish sites (Theischinger & Hawking 2006).

biology and behaviour. The larva of this species was partially illustrated by Theischinger & Hawking (2006). Its erratic behaviour drives it far from aquatic environments. It hunts in both open places and in forest clearings (Davies 2002).

Status. Lacking sufficient information about its status in New Caledonia, we assign it as DD.

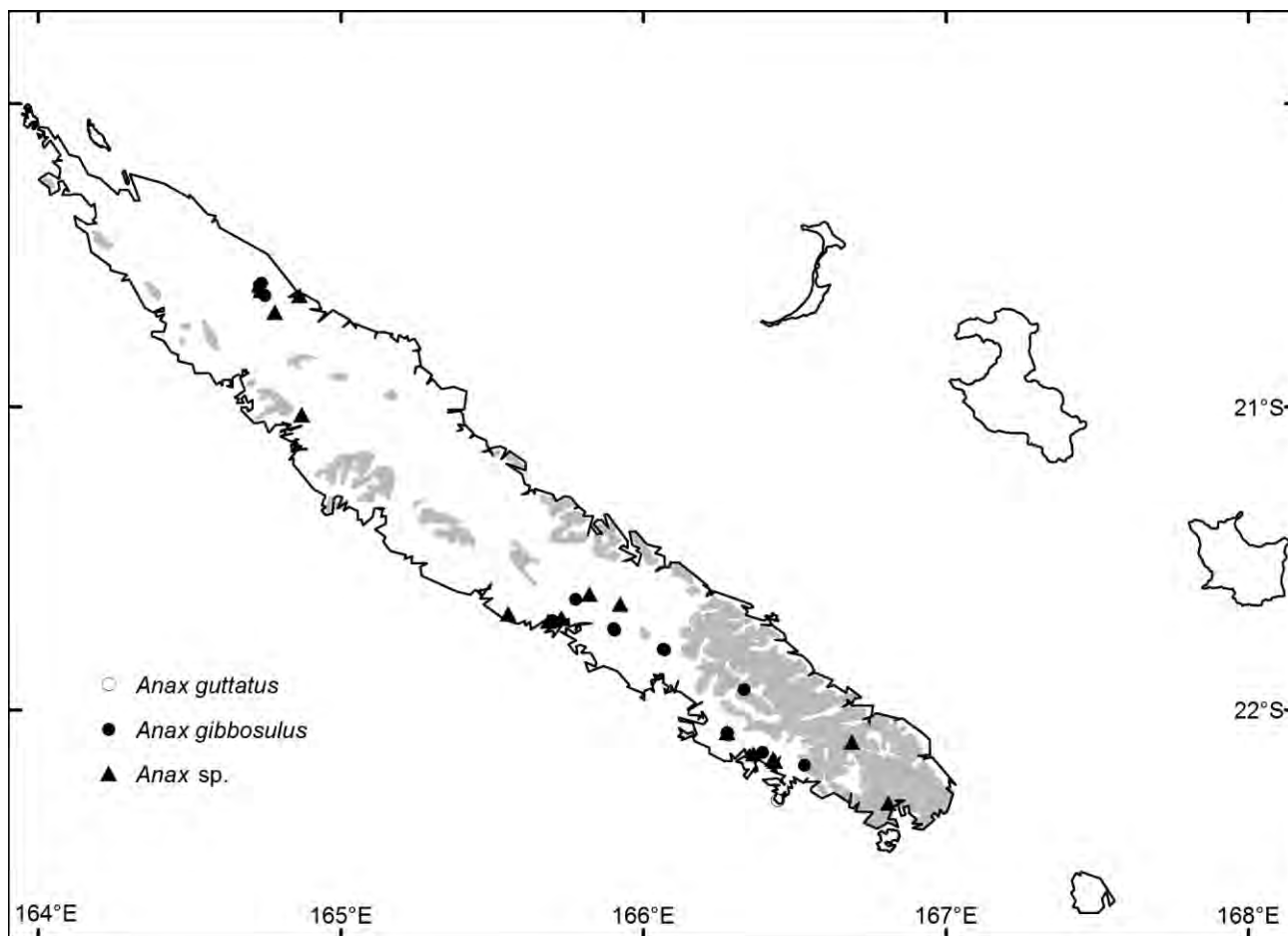


Figure 44. Records of *Anax gibbosulus/guttatus*.

***Anax guttatus* (burmeister, 1839)**

(Fig. 45)

Aeschna guttatus Burmeister, 1839: 840; *Anax magnus* Rambur, 1842; *Anax gibbosulus* (nec Rambur?) Hagen, 1867; *Anax goliathus* Fraser, 1922.

Distribution (Fig. 44). This species is known from the whole Oriental biogeographic region, from Papua New Guinea, the north of Australia and most South-west Pacific islands (Tsuda 2000), as well as from Tahiti (Paulian 1998). In New Caledonia, we collected it in the Pocquereux valley (La Foa municipality) and in the Nakutakoin swamp in Dumbéa. Several specimens collected in Nouméa are represented in the ONNC collection. The two *Anax* species (*A. guttatus* and *A. gibbosulus*) are so similar that Paulian (1998) suggested that they might be only just two extreme forms of the same species.

Habitat. This species reproduces in standing water, including brackish sites (Theischinger & Hawking 2006).

biology and behaviour. The larva was partially illustrated by Theischinger & Hawking (2006). Its habits are similar to *A. gibbosulus*.

Status. Lacking sufficient information about its status in New Caledonia, we rank *A. guttatus* as DD.

***Anax papuensis* (burmeister, 1839)**

(Fig. 46)

Aeschna papuensis Burmeister, 1839: 841; *Anax congener* Rambur, 1842; *Hemianax papuensis* (Burmeister, 1839).

Systematics. This species was formerly placed in the genus *Hemianax* Selys, 1883 but various recent authors have treated this as a synonym of *Anax* Leach, 1815 (Heidemann & Seidenbusch 2002; Dijkstra & Lewington 2007; Boudot *et al.* 2009; Kalkman *et al.* 2010c; Lopau 2010). we follow Orr & Kalkman (2015) in placing *A. papuensis* in the genus *Anax*.

Distribution (Fig. 47). This Australasian species extends to eastern Indonesia (Tsuda 2000) and, during migrations, it reaches the islands of Sumba, Coco-Keelings, Lord Howe and Raoul (Rowe 1987). In New Caledonia, only one specimen has been caught in Nouméa, on 20th November 1955 (winstanley 1983). we did not observe this species, but Davies (2002) reports *A. papuensis* as “frequently seen in all parts of New Caledonia in season” but he did not specify any locality. Only winstanley (1983) indicates the collection of two males of *A. papuensis* on 20th February 1955 by J. Rageau in Nouméa.

Habitat. *Anax papuensis* frequents standing waters and, occasionally, quiet sectors of springs (Theischinger & Hawking 2006).

biology and behaviour. This migratory species was studied by Rowe (1987) whose observations we summarize. Eggs are laid in plants and measure from 1.5 to 1.7 mm long and develop within 16 days at a temperature of 21–24°C. Depending on temperature, the larval cycle takes between 100 to 250 days in Australia (probably similar in New Caledonia), whereas in New Zealand, it may last two years. In laboratory conditions, emergence starts early in the morning and takes two and a half hours. The larvae are between 40 and 45 mm long. Males patrol a territory of about 50 to 60 m of riverbank waiting for females to appear. Approaching water, the female is quickly seized by the closest male, and then the couple lands on nearby vegetation. Eggs are laid mainly in tandem and occasionally females may oviposit alone (Rowe 1987). The female inserts her eggs into floating or emergent vegetation. The larva was described by Hawking (1986) and its habitus is shown by Rowe (1987).

Status. As it has been only recorded once with certainty and this species appears to be migratory, we considered it to be DD.



FIGURE 45. *Anax guttatus*, male.



Figure 46. *Anax papuensis*, male, New Zealand (M. Ashby).

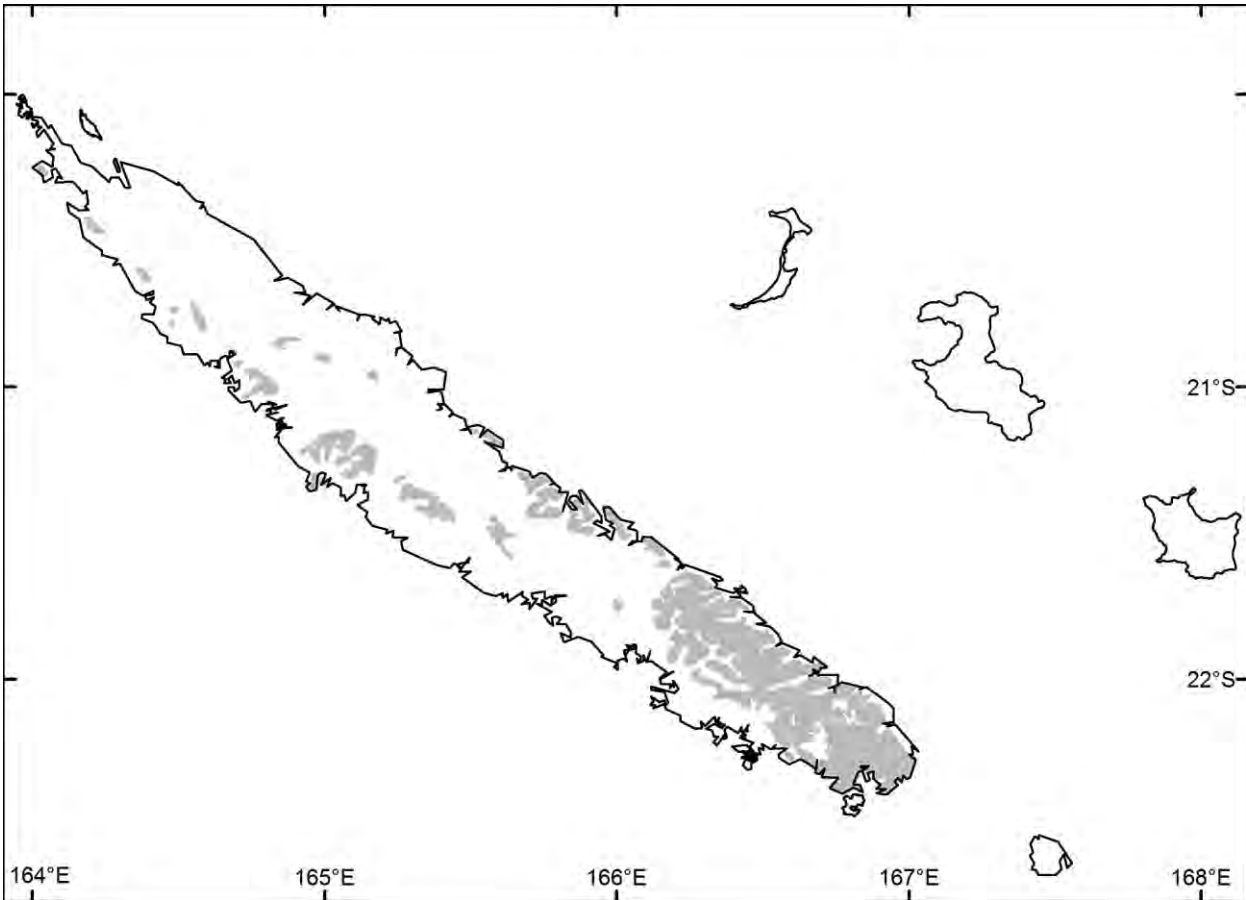


Figure 47. Records of *Anax papuensis*.

***Austrogynacantha heterogena* Tillyard, 1908**

(Fig. 48)

Austrogynacantha heterogena Tillyard, 1908: 425.

Distribution (Fig. 49). This species occurs all over Australia (Tsuda 2000). In New Caledonia, it is only known from the municipality of Koné and from the Dumbéa valley (Davies 2002). This very fragmented distribution suggests either the species is newly arrived from Australia or there has been insufficient sampling effort.

Habitat. This species frequents standing waters (Theischinger & Hawking 2006).

biology and behaviour. *Austrogynacantha heterogena* has crepuscular habits. It is attracted by light in the evening and can enter houses (Davies 2002). Its larva is briefly illustrated by Theischinger & Hawking (2006).

Status. Due to insufficient information about the status of *A. heterogena* in New Caledonia, we consider the species to be DD.



FIGURE 48. *Austrogynacantha heterogena*, male, Australia (M. Tattersall).

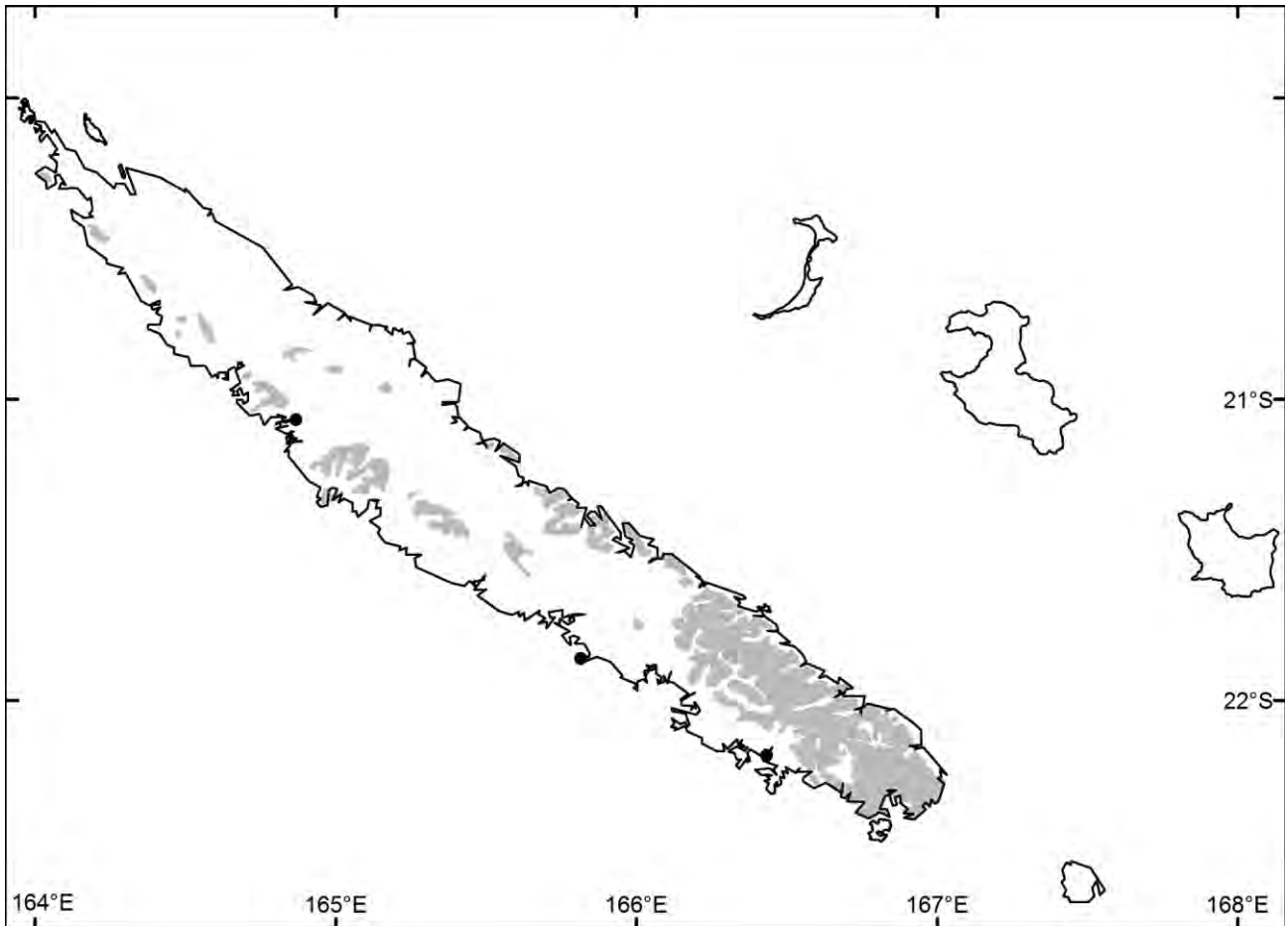


Figure 49. Records of *Austrogynacantha heterogena*.

***Gynacantha rosenbergi* Kaup in brauer, 1867**

(Fig. 50)

Gynacantha rosenbergi Kaup in Brauer, 1867: 295; *Gynacantha bonguensis* Foerster, 1898; *Acanthagyna rosenbergi* Kimmins, 1953; *Acanthagyna dobsoni* Fraser, 1951.

Distribution (Fig. 51). This species is known from Indonesia, Papua New Guinea, the North-East of Australia and Fiji, Vanuatu and the Solomon islands (Tsuda 2000). we observed it in La Foa and in Nouméa, where it was formerly recorded by Kimmins (1953). This species is rarely encountered despite Davies (2002) describing it as “widely spread, even abundant in New Caledonia”. One specimen collected in October 2004 in La Foa (Nily) is held in the CXMNC collection.

Habitat. Theischinger & Hawking (2006) wrote: “probably inhabits still waters”.

biology and behaviour. *Gynacantha rosenbergi* has crepuscular habits, especially when foraging. It visits all habitats, including towns where individuals are attracted to artificial light. According to Theischinger & Hawking (2006), its larva is unknown.

Status. Because there is insufficient information on the status of *G. rosenbergi* in New Caledonia, we rank it as DD. we assigned all records to *G. rosenbergi* by supposition because so far this is the only representative of the genus known to be present in the country. However, Pacific *Gynacantha* are poorly studied and there is a possibility that some of the previous records of *G. rosenbergi* need to be transferred to another species.



A



B

FIGURE 50. *Gynacantha* spp.: a) *G. rosenbergi*, male, Australia (G. winterflood), b) *Gynacantha* sp., female (J. Theuerkauf)

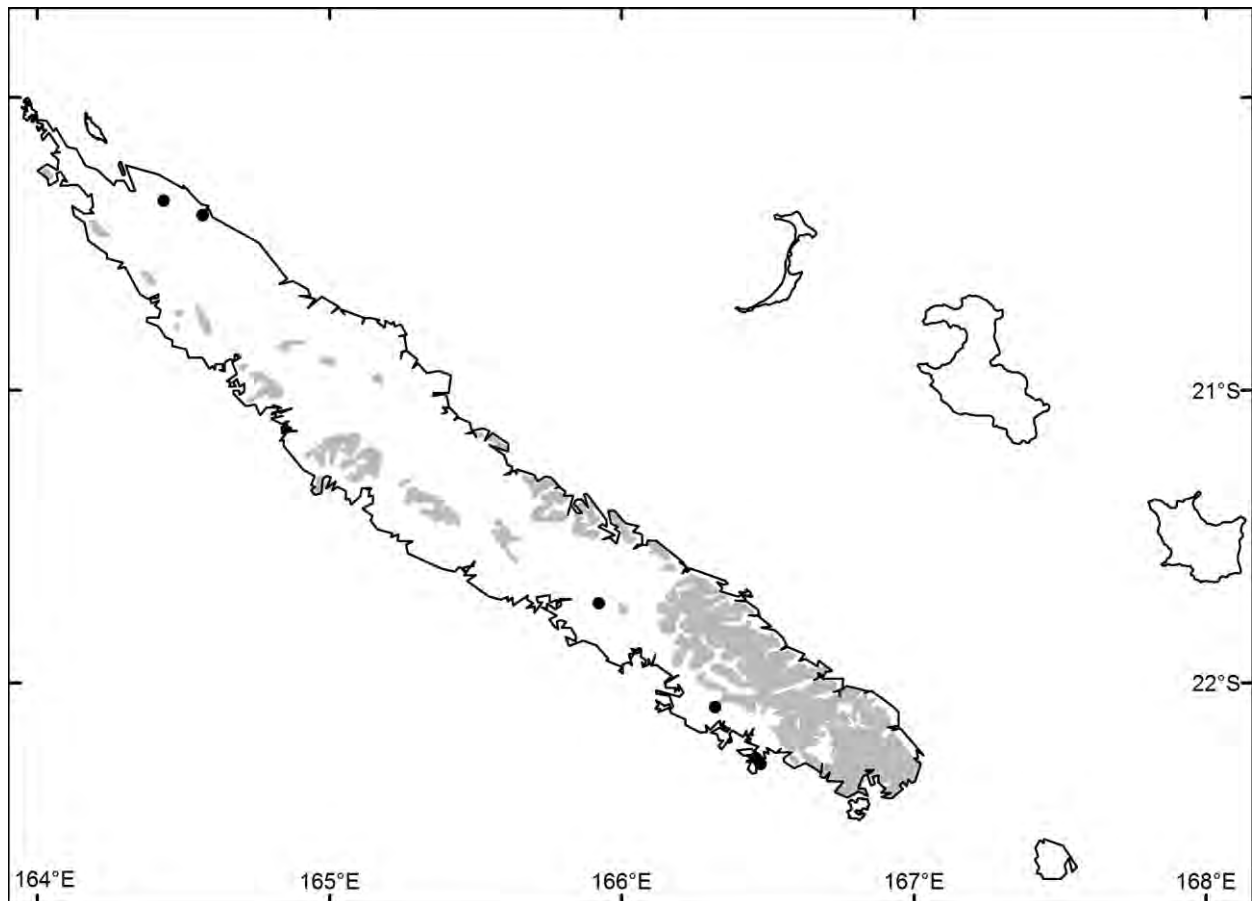


Figure 51. Records of *Gynacantha* spp.

***Oreaeschna dominatrix* Vick & Davies, 1990**

(Fig. 52)

Oreaeschna dominatrix Vick & Davies, 1990: 188.

Systematics. *Oreaeschna dominatrix* belongs to a genus that includes only two species, of which the other one, *O. dictatrix*, is endemic to Mounts Cyclops in New Guinea. *Aeshna* (*Adversaeschna*) *watson*, 1992 and *Oreaeschna* *Lieftinck*, 1937 present several convergent morphologic characters (Vick & Davies 1990). In addition, *A. brevistyla caledonica* shows a strong resemblance to *O. dominatrix*.

Distribution (Fig. 53). New Caledonian endemic. This species is known from 15 localities, mainly in the Plaine des Lacs and in the valleys of Rivière Blanche and Rivière Bleue. However, some individuals have been collected up to the Mont Panié Massif in the north of Grande Terre and there are also two reports from Lifou.

Habitat. we always encountered this species at streams with large and deep pools or partly sunlit, fairly wide, deep and slow flowing reaches along gallery forests. It seems to have a preference for ultramafic soils.

biology and behaviour. Flying 1–2 m above the water surface, males patrol sections of about 10 m along the stream or they hover over large pools. From time to time, they rest for between a few seconds to about 10 minutes. The females remain in riparian woodlands except when breeding. In February 2004, Grand (2005) observed a pair mating above the water surface, but the couple rapidly disappeared towards the canopy. The larval biology of the species is unknown. However, DG collected several exuviae assigned to this species.

Status. Two third of the *O. dominatrix* population is concentrated in the Plaine des Lacs and surroundings. Its occurrence in the North Province is not confirmed and it is unlikely that the species reproduces on Lifou which does not have running water. we rank it as VU.



Figure 52. *Oreoeschna dominatrix*, male.

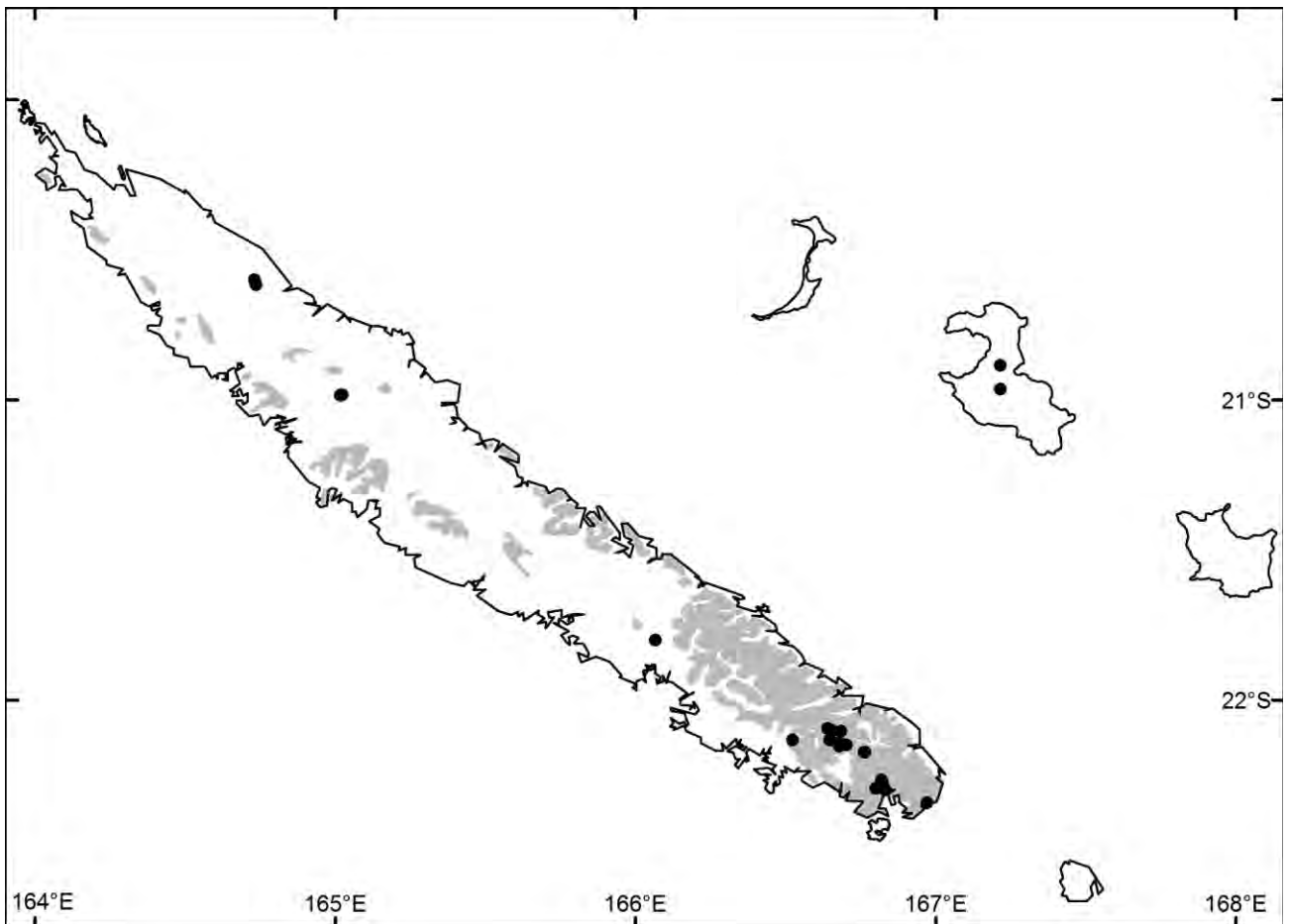


Figure 53. Records of *Oreoeschna dominatrix*.



FIGURE 54. *Hemicordulia fidelis*: a) male, b) female.

Family Corduliidae Leach, 1815

This worldwide family is represented in New Caledonia by two genera with three species. Their body colour varies from glossy green to matt black, sometimes with small yellow to brown spots. Corduliids are very fast flying, typically rather fugitive and can often be found well away from the water. Once mating tandems are formed, couples hang on small twigs, sometimes away from water. Females lay their eggs alone, directly into water. Another species, *Hemicordulia oceanica*, was long considered to be native to New Caledonia, but now it is clear that this species is restricted to the Society Islands, French Polynesia (Lietinck 1975).

Hemicordulia fidelis MacLachlan, 1886

(Fig. 54)

Hemicordulia fidelis MacLachlan, 1886: 104.

Distribution (Fig. 55). Regional endemic. Also found in Vanuatu (Tsuda 2000), this species is widely distributed in New Caledonia, except for the far north, Île des Pins and the Loyalty Islands, which is its type locality. Bigot (1985) collected several specimens in Prony, Touaourou and on Île des Pins. One specimen captured in November 2001 in the Pocquereux valley (La Foa) is held in the CXMNC collection.

Habitat. *Hemicordulia fidelis* breeds in a large variety of freshwater habitats: swamps, ponds, lakes, large pools in creeks and calm parts of streams and rivers. It avoids steep creeks with low water levels but seems able to tolerate ultramafic soil.

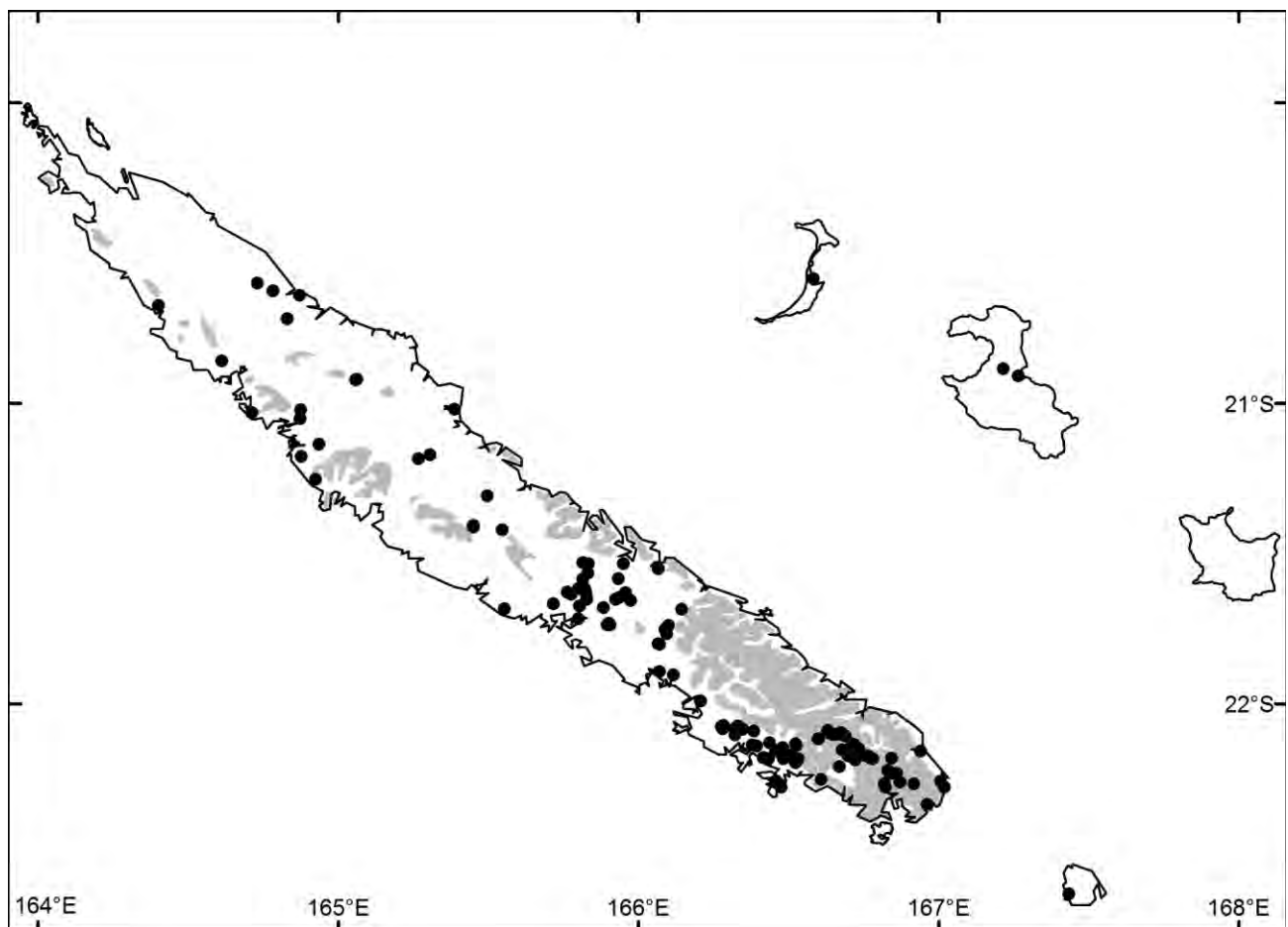


Figure 55. Records of *Hemicordulia fidelis*.

biology and behaviour. Exuviae are found, sometimes numerous, hanging on bank vegetation up to a height of 2 m. Adults often wander far from water, while males patrol for a long time defending sites from 20–50 m along banks. They are very nervous. Females lay their eggs alone, rapidly touching the water surface a dozen times to release egg clumps with a quick and jerky flight.

Status. we assign *H. fidelis* to the category LC.

Hemicordulia hilaris Lieftinck, 1975

(Fig. 56)

Hemicordulia hilaris Lieftinck, 1975: 154.

Distribution (Fig. 57). Pacific-wide. This species is recorded from more than 15 localities of Grande Terre but its distribution is not continuous. Almost all localities are south of the Yaté lake. Bigot (1985) collected some specimens in Dumbéa.

Habitat. *Hemicordulia hilaris* seems to prefer ponds but can sometimes be observed near rivers. It prefers sunny and shallow swamps and ponds with very dense, low growing reed beds. The species tolerates ultramafic soil.

biology and behaviour. Adults often wander far from water. Males patrol oviposition sites. Mating was not observed, but females lay their eggs in the same way as the previous species. Exuviae are found hanging, slightly inverted, on rock walls out of the water.

Status. In New Caledonia, the species occurs in small populations in restricted areas. Therefore, we consider this species to be locally VU.



FIGURE 56. *Hemicordulia hilaris*, male.

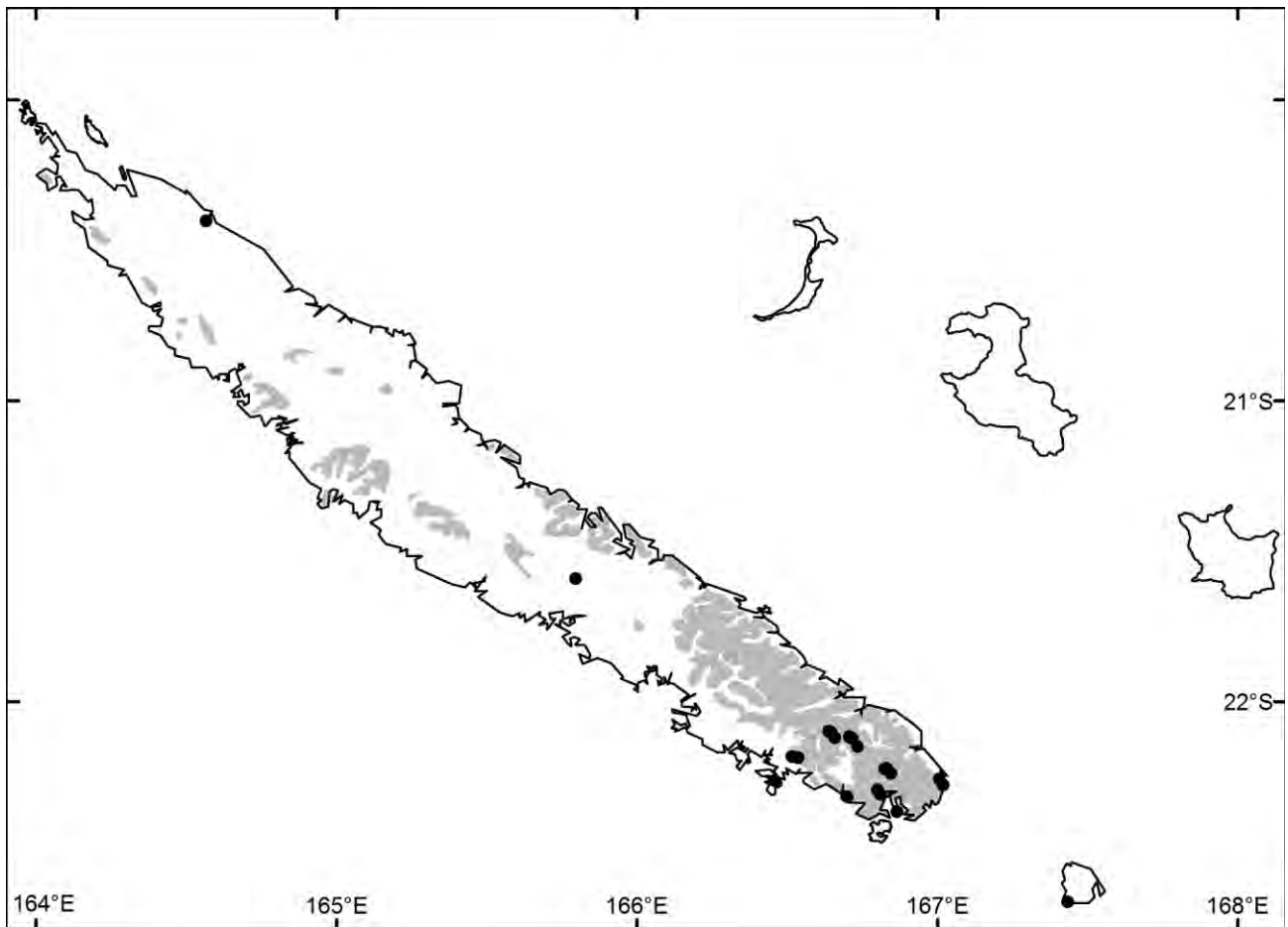


Figure 57. Records of *Hemicordulia hilaris*.

***Metaphya elongata* Campion, 1921**

(Fig. 58)

Metaphya elongata Campion, 1921: 64.

Distribution (Fig. 59). Endemic to New Caledonia. This small Corduliidae belongs to a genus with four species present in Australia, Borneo, New Guinea, and New Caledonia (Fleck 2007). It is recorded from more than ten localities, almost all in the southern tip of Sud Province. Karube (2000) observed this species 20 km north-east of Nouméa, which is its northernmost known point of occurrence.

Habitat. *Metaphya elongata* reproduction sites are currently unknown, but considering our observations, they could be in certain waterbodies of the Plaine des Lacs. The species seems to prefer ultramafic soil.

biology and behaviour. Most records are of vagrant individuals. However, in February 2011, DG observed a few males around a pond in the north of Prony, two females approached the pond and disappeared immediately into low reeds growing in the water. From one hundred eggs collected from two females on the shores of the Lac en Huit in mid February 2004, Fleck (2007) reared five specimens to the final stadium in the laboratory.

Status. Restricted to a very small area that is threatened by mining, *M. elongata* has mostly been observed in singles and its breeding sites are still unknown. we rank the species as EN.



Figure 58. *Metaphya elongata*, male.

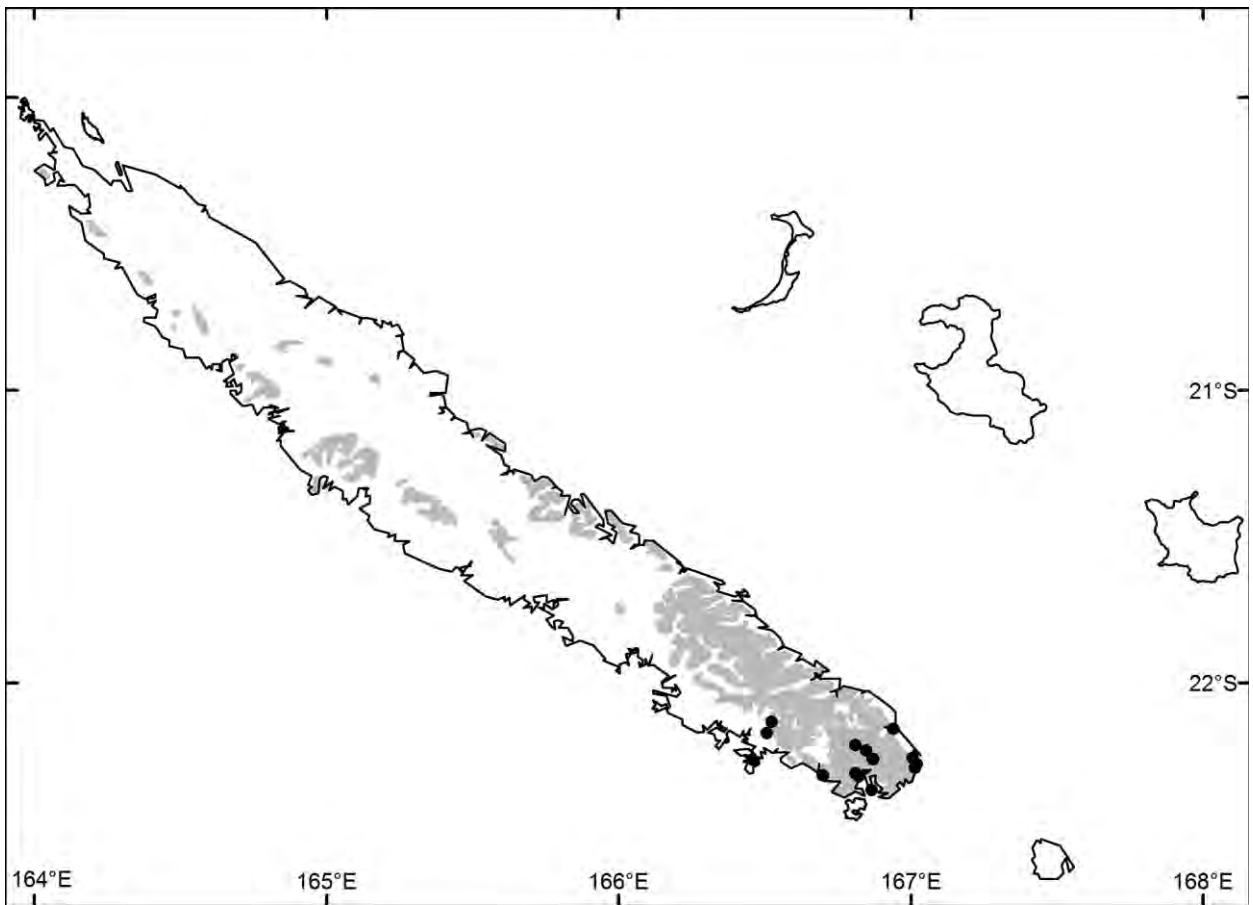


Figure 59. Records of *Metaphya elongata*.



Figure 60. *Synthemis ariadne*, male.

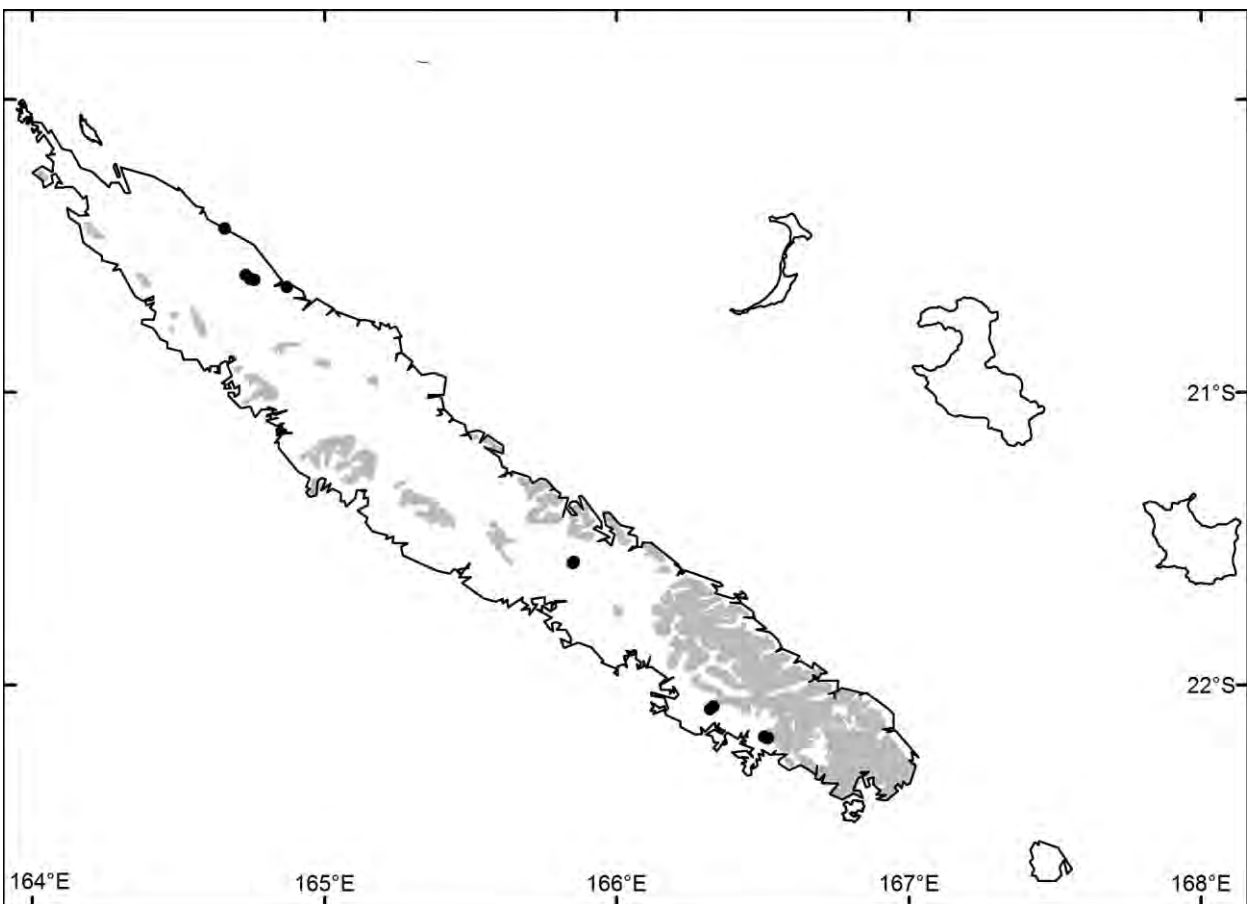


Figure 61. Records of *Synthemis ariadne*.



Figure 62. *Synthemis campioni*: a) male, b) female.

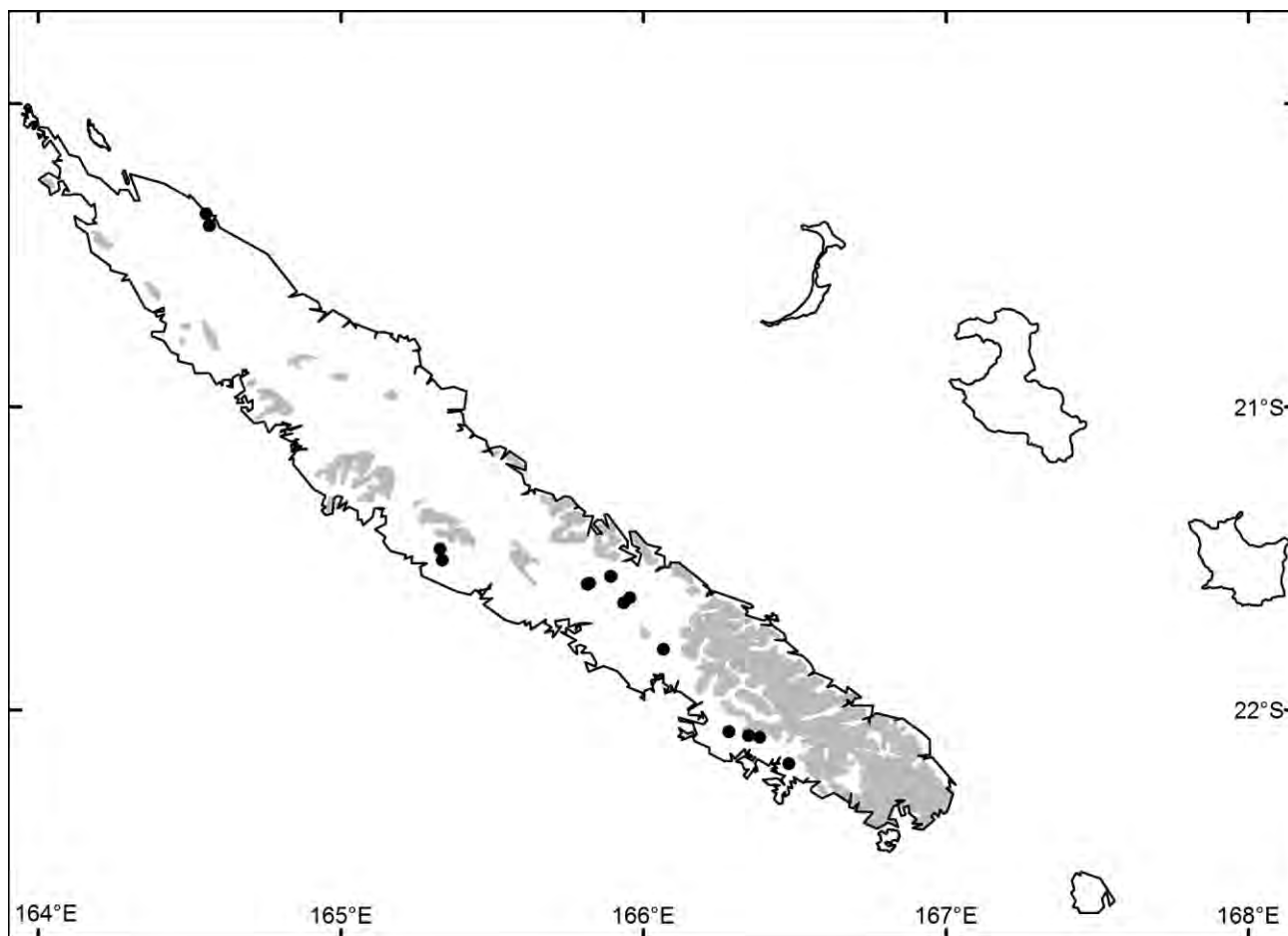


Figure 63. Records of *Synthemis campioni*.

Family Synthemistidae Tillyard, 1917

In its traditional sense (Silsby 2001; Theischinger & Hawking 2006; Michalski 2012; Orr & Kalkman 2015), this family is endemic to the Australasian region. It includes eight genera and at least 44 species. Synthemistidae are represented on Grande Terre by eight endemic species of the genus *Synthemis*. All New Caledonian species are endemic and common along running water. The taxonomic status of this family is still not fully resolved.

Synthemis ariadne Liefertinck, 1975

(Fig. 60)

Synthemis ariadne Liefertinck, 1975: 160.

Distribution (Fig. 61). Endemic to Grande Terre. This species is known from six localities spread along the central range. winstanley (1984c) collected the first female in November–December 1981. Its apparent rarity is probably due to its early flight period, from mid-October to late December, a time of the year collectors seldom search for Odonata.

Habitat. *Synthemis ariadne* frequents mountain creeks and streams, covered by forests, on non-ultramafic soil.

biology and behaviour. The biology of this species is little known. Its final stadium larvae, described by supposition (winstanley 1984b; Fleck 2005), lives in small creeks and their tributaries. Hiding among rocks, it may occasionally be found with *S. fenella* Campion, 1921. Emergence occurs not far above water surface (winstanley

1984b). Fleck (2005) reared several larval stages in laboratory conditions without obtaining any adults because its development was so slow. This author concluded that the larval development takes at least four years.

Status. *Synthemis ariadne* is known from a very few localities scattered over the main island. Although its habitat is not immediately threatened, we rank it EN, because of its rarity.

***Synthemis campioni* Lieftinck, 1971**

(Fig. 62)

Synthemis campioni Lieftinck, 1971: 48.

Distribution (Fig. 63). Endemic to Grande Terre. This species was found in at least 10 localities mainly in the southern half of the island, where the sampling effort was much more intense than elsewhere.

Habitat. Mountain creeks and streams in forests, but also in large fast-flowing streams in the lowlands. *Synthemis campioni* avoids ultramafic lands.

biology and behaviour. Larvae develop in relatively calm water along the stream banks in places where partly submerged roots of large trees slow the current. Exuviae are found on trunks and boulders 0.2–1.4 m above the water surface. Males patrol stretches of a bank (6–30 m). Mating (2 observations) occurs during flight, 0.7–1.2 m above the water surface, for 20–30 s, along the stretch of the bank that was patrolled by the male.

Status. *Synthemis campioni* is probably more widely spread than its known distribution and its populations can be large. As a precaution, we rank it as EN, as only a dozen localities are known.

***Synthemis fenella* Campion, 1921**

(Fig. 64)

Synthemis fenella Campion, 1921: 61.

Distribution (Fig. 65). Endemic to Grande Terre. with almost 60 known localities, it is widespread along the main mountain range, but also in the lowlands. Its populations are often large. A specimen collected on 3rd May 1979 in the Thy forest is held in the ONNC collection.

Habitat. Fast-flowing forest creeks and streams.

biology and behaviour. This species is easy to distinguish and its presence is often revealed by the exuviae clinging to banks of streams. Larvae emerge before noon and hang from tussocks, tree trunks, rock walls or large pebbles at a height of 0.1 m. In the early morning, males are the first *Synthemis* to fly over the water, sometimes before 0800 h. They are inconspicuous and suspicious of larger species. They arrive suddenly over calm pools ranging in surface area from a few dm² to 1–2 m². They fly swiftly, darting hither and thither 15–25 cm above the water surface. In some places, they hover 2–3 seconds, to inspect hidden places, where a female may lay eggs. If another male approaches, a brief chase toward the canopy follows, and only one of them will return. Before visiting oviposition sites, females wait for males to leave. Having found a suitable puddle, they first inspect it flying just above (10–15 cm), then they begin a quick, agitated flight. with the tip of their abdomen, they touch the water surface several times to release their eggs. Oviposition may be disturbed by a male or by an assault by another *Synthemis* species. If the female has not seen a male approaching, the male will hold the female immediately (one observation) and the couple rises slowly to disappear into the canopy. Mating probably takes place on (or attached to) a twig. This species disappears early in the afternoon, when there are too many males of other *Synthemis* species. The larva was described by Lieftinck (1976).

Status. widespread and abundant. we rank *S. fenella* as LC.



FIGURE 64. *Synthemis fenella*: a) male, b) female.

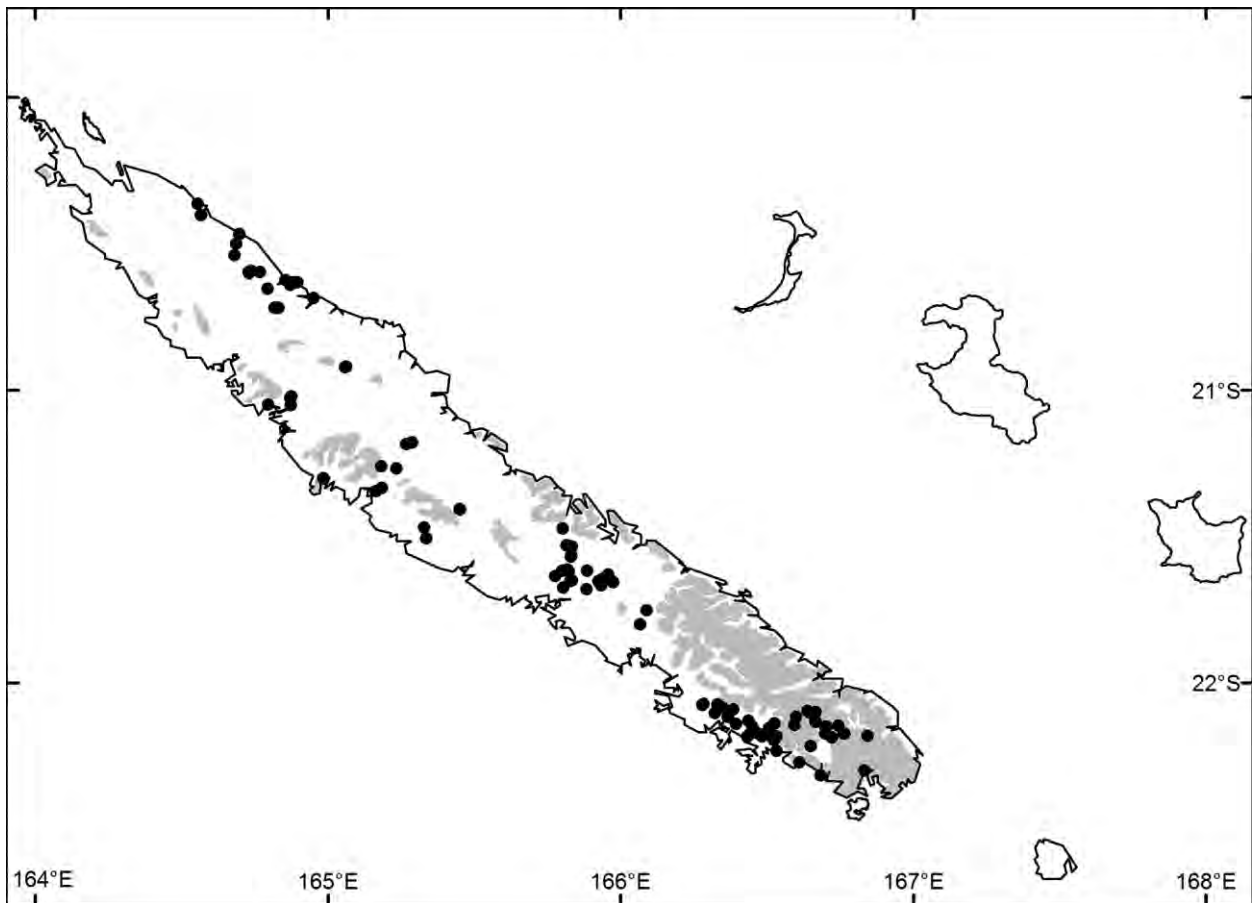


Figure 65. Records of *Synthemis fenella*.



Figure 66. *Synthemis flexicauda*: male.

Synthemis flexicauda **Campion, 1921**

(Fig. 66)

Synthemis flexicauda **Campion, 1921**: 57.

Distribution (Fig. 67). Endemic to Grande Terre. This rare species is only known from three localities in the southern part of the island.

Habitat. Rocky creeks on steep slopes in open forest. This species is encountered at higher altitude on ultramafic soil.

biology and behaviour. The few exuviae collected were on boulders in the stream not far above the water. Males become active along creeks around 09:00 h, flying rapidly and continuously back-and-forth above rapids connecting pools. when resting they hang under branches of shrubs. The female was not observed.

Status. Only five *S. flexicauda* males were observed on a tributary of the Dumbéa River, but the bushfire that damaged the site in 2009 does not seem to have severely affected the local population of this species. Pending a better understanding of its distribution, we rank the species CR.

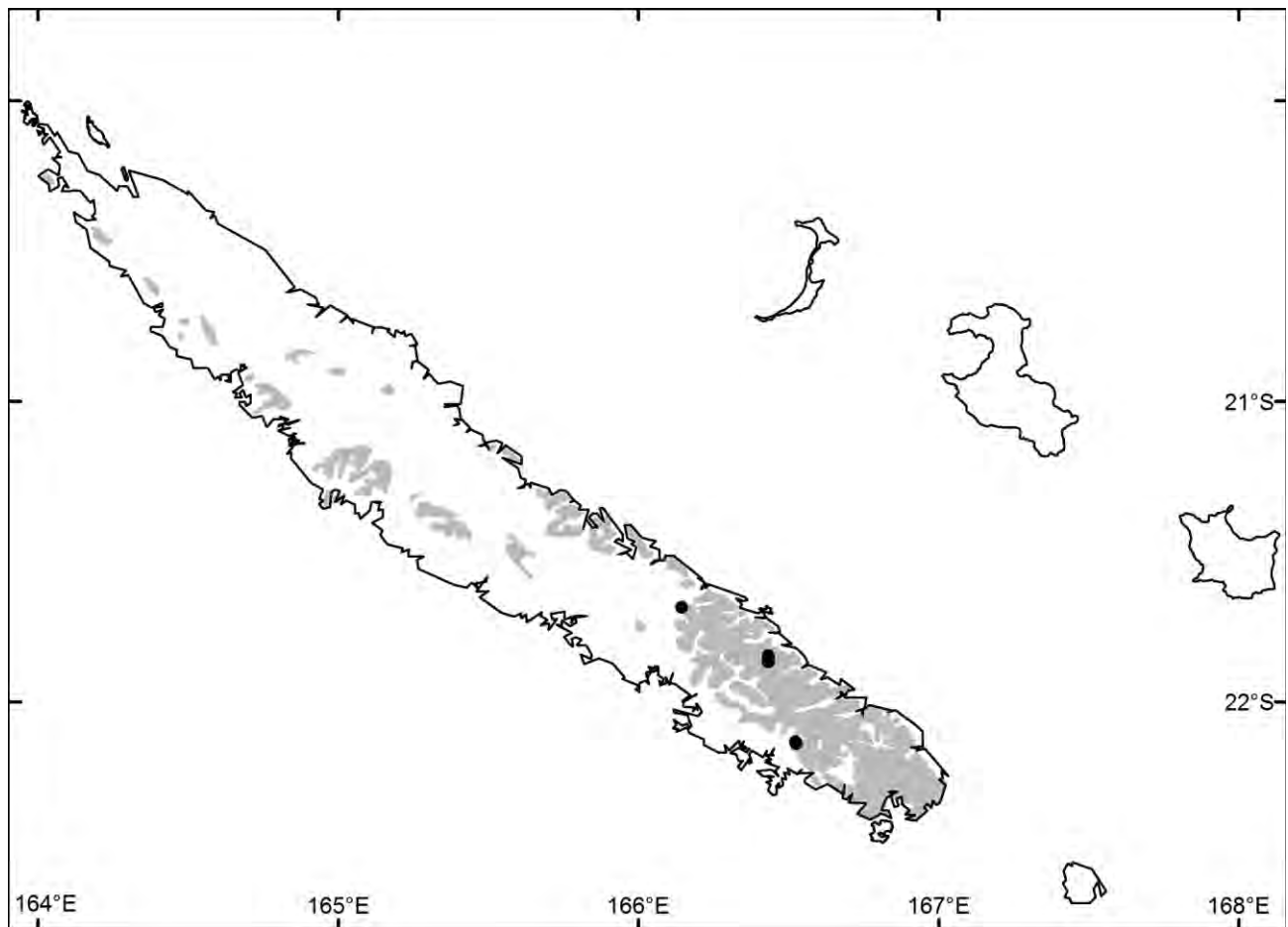


Figure 67. Records of *Synthemis flexicauda*.

Synthemis miranda **Selys-Longchamps, 1871**

(Fig. 68)

Synthemis miranda **Selys-Longchamps, 1871**: 557.

Distribution (Fig. 69). Endemic to Grande Terre. This large species (wing span up to 90 mm) is recorded from at least 35 localities around the island. Bigot (1985) collected a female in the Baie du Prony. One specimen collected in January 1957 in the Thy Forest is held in the ONNC collection and another, collected in March 1998 in La Foa (Pocquereux valley), is held in the CXMNC collection.

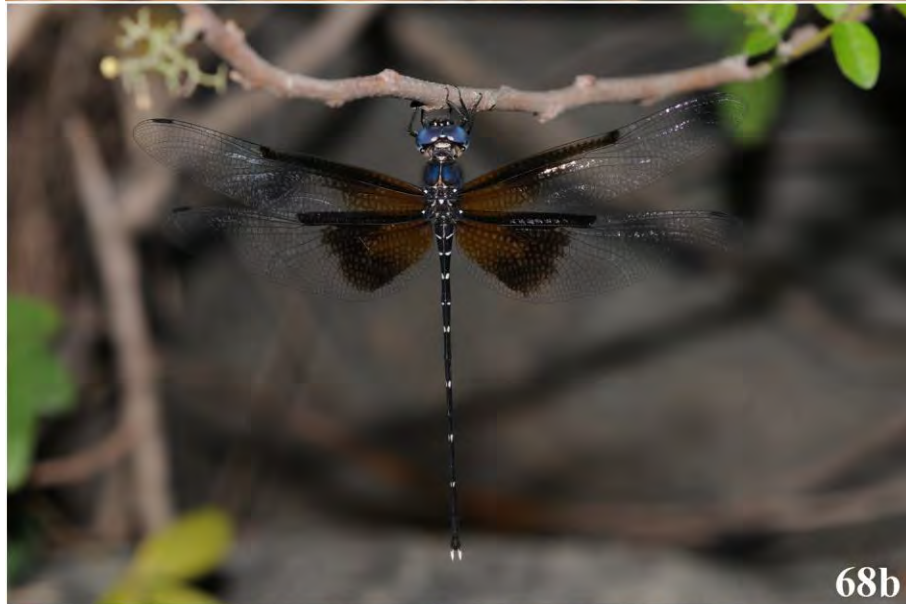


FIGURE 68. *Synthemis miranda*: a) male, b) female f. *typica*, c) female f. *extenuata*.

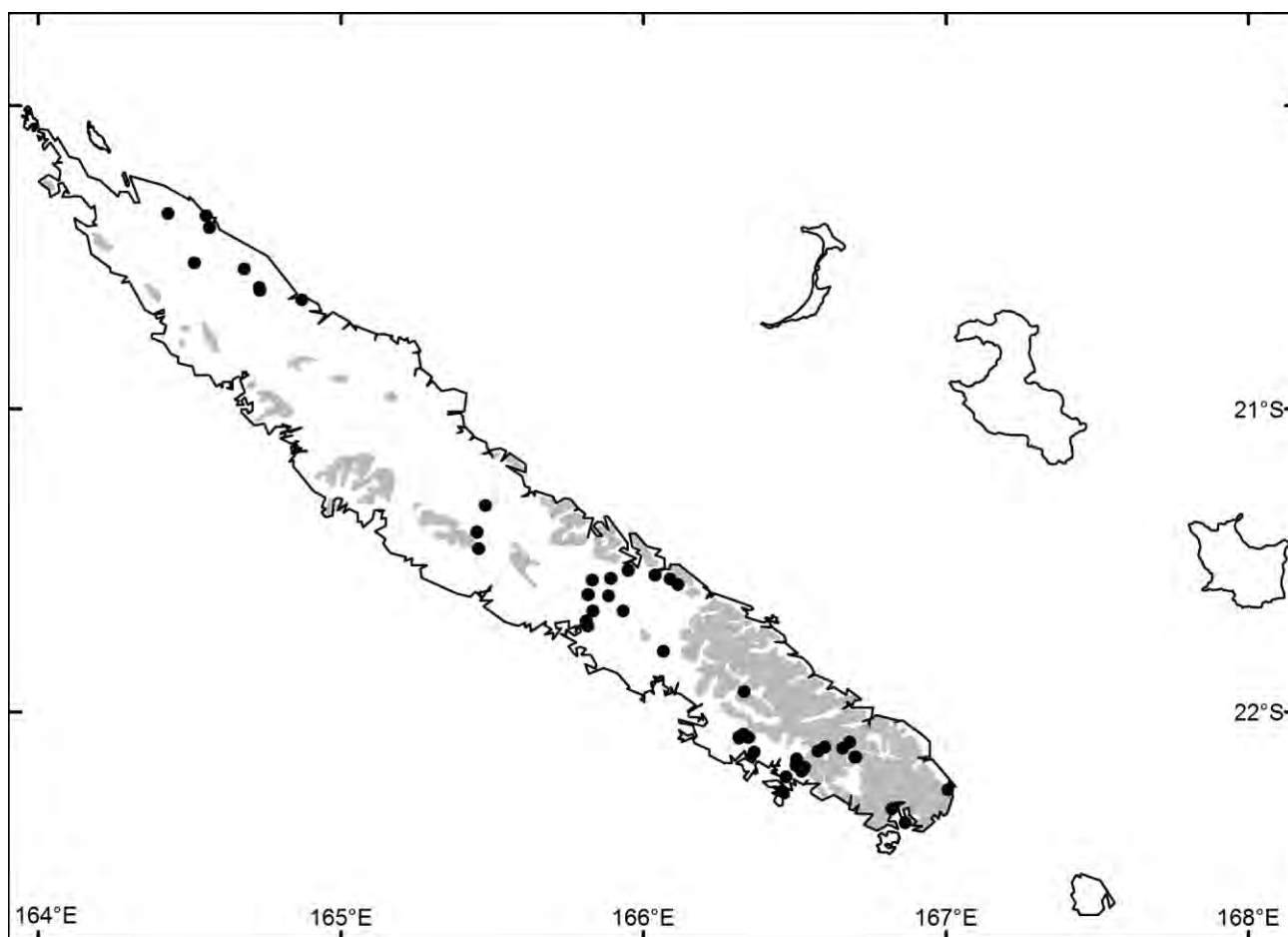


Figure 69. Records of *Synthemis miranda*.

Habitat. *Synthemis miranda* occurs on mountain forest creeks and streams. It can also sometimes be found in the lowlands. This species tolerates ultramafic soils.

biology and behaviour. *Synthemis miranda* is highly territorial, males patrol around shallow ponds (4–5 m²) or puddles near very fast-flowing creeks. However, oviposition sites are located in pools that are more or less disconnected from the creek. Males are highly aggressive towards other males. Resident males attack other males or any specimen belonging to smaller species that enter their territory. If a female enters a male's territory, the male will capture her immediately. After tandem formation mating lasts for about 40 seconds in flight 0.6–1.5 m above the ground, while the couple complete six to eight chaotic circling flights over the oviposition site (more than 10 observations). Once released, the female will only lay in the area previously patrolled by the male. She lays eggs onto a substrate with plant debris covered with a film of water (up to a few mm). The exuviae of *S. miranda* are sometimes found more than 3 m away from the water, clinging to tree trunks, up to 2.5 m above the ground. The larva was described by Lieftinck (1976). On the 22nd January 2010, DG discovered, along the Sanatorium stream (Païta), a pair of *S. miranda* in the wheel position; the female in this case had extensive wing coloration. Under the still conditions, this couple hung under a twig at more than 5 m height and was observed for more than 10 minutes. It is possible, if not probable, that this species may have two methods of mating, as the Afro-European Libellulidae *Crocothemis erythraea* (Brullé, 1832) that normally mates in flight for about ten seconds, but may perch to form a wheel depending on the strength of wind and the presence of congeners.

Morphological variations. There is variation in the wing colour pattern in females. Typical females have a strong transparent saffron tint that covers the wing from the basis to the discoidal cell. However, in some females, the tint ranges from deep yellow to light brown and may reach the nodus. Based on sympatric occurrence from the northeast of Grande Terre, Marinov & Richards (2013) formally recognised two forms – f. *typica* which includes the holotype female and f. *extenuata* for the females with reduced colour on the wings. These names were proposed for convenience in recording future observations and do not reflect the actual abundance, nor do they have formal

nomenclatorial status recognised by the ICZN. A flight of twenty individuals was observed in a creek near the Mont Koghis auberge. At least five or six females had strongly coloured wings, hovering quietly at a height of 4–10 m.

Status. *Synthemis miranda* is widely distributed over Grande Terre with large populations. we rank this species as LC.



FIGURE 70. *Synthemis montaguei*: a) male, b) female.

Synthemis montaguei Campion, 1921

(Fig. 70)

Synthemis montaguei Campion, 1921: 55.

Distribution (Fig. 71). Endemic to Grande Terre. This species appears to be close to *S. miranda*, it is recorded from more than 20 localities all over the island, especially at low altitude.

Habitat. It prefers watercourses in the lowland forest (streams to rivers), deep, rather wide, with a moderate current. More rarely, it is found at mid altitude in slow reaches of streams.

biology and behaviour. Numerous exuviae have been found on the trunks of trees along rivers 0.5–2 m above the ground. Males appear moderately territorial, regularly patrolling sections of the bank 15–30 m long. They often rest for long periods, hanging from twigs or on tufts of grass. One female was observed very early in an area frequented by many males. In the late afternoon up to 15–25 individuals may hunt until dusk in the same area in clearings near water.

Status. Less abundant than the previous species, *Synthemis montaguei* rarely has large populations. Nevertheless, we consider this species to be at low risk (LC).

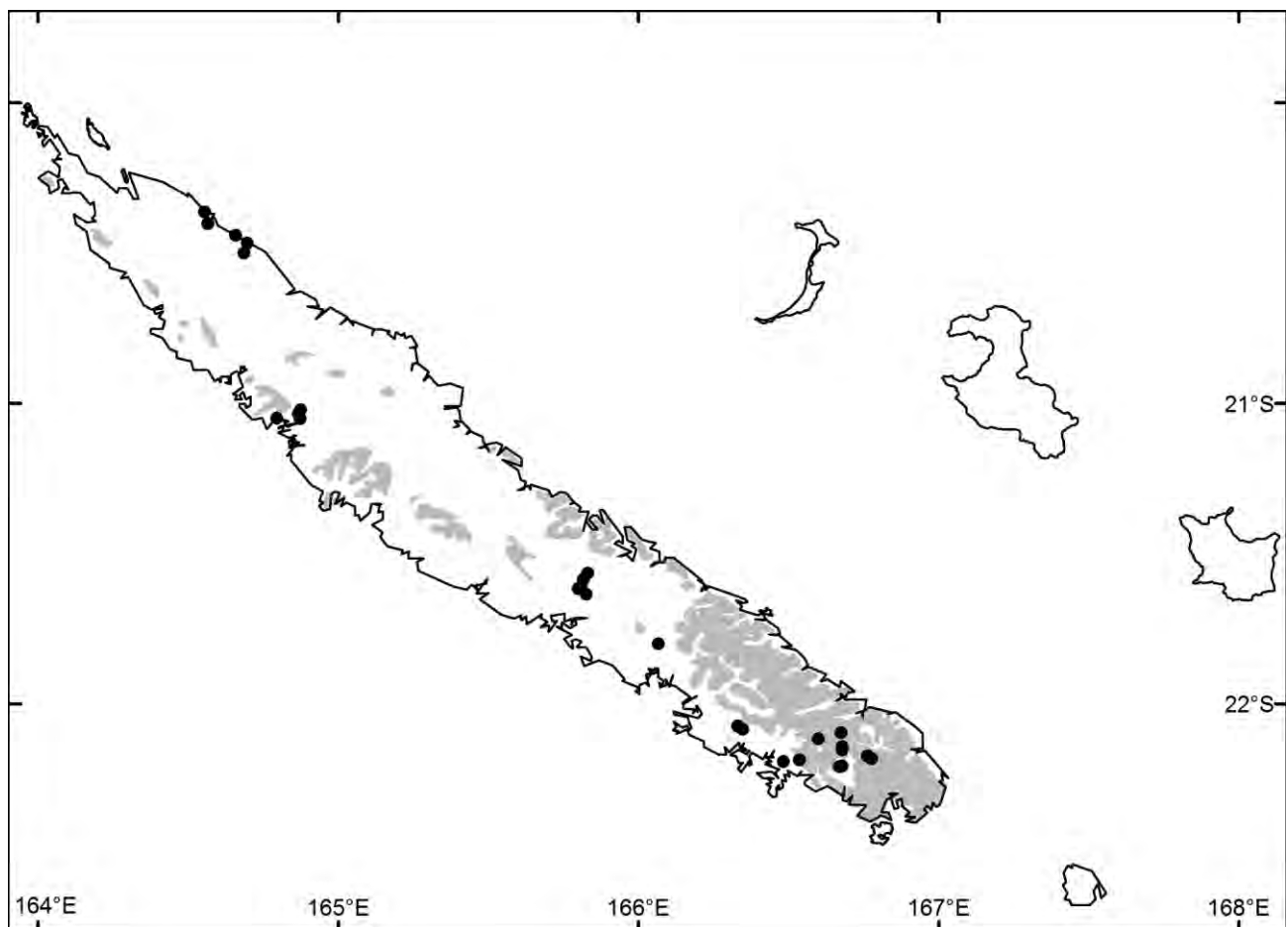


Figure 71. Records of *Synthemis montaguei*.

Synthemis pamela Davies, 2002

(Fig. 72)

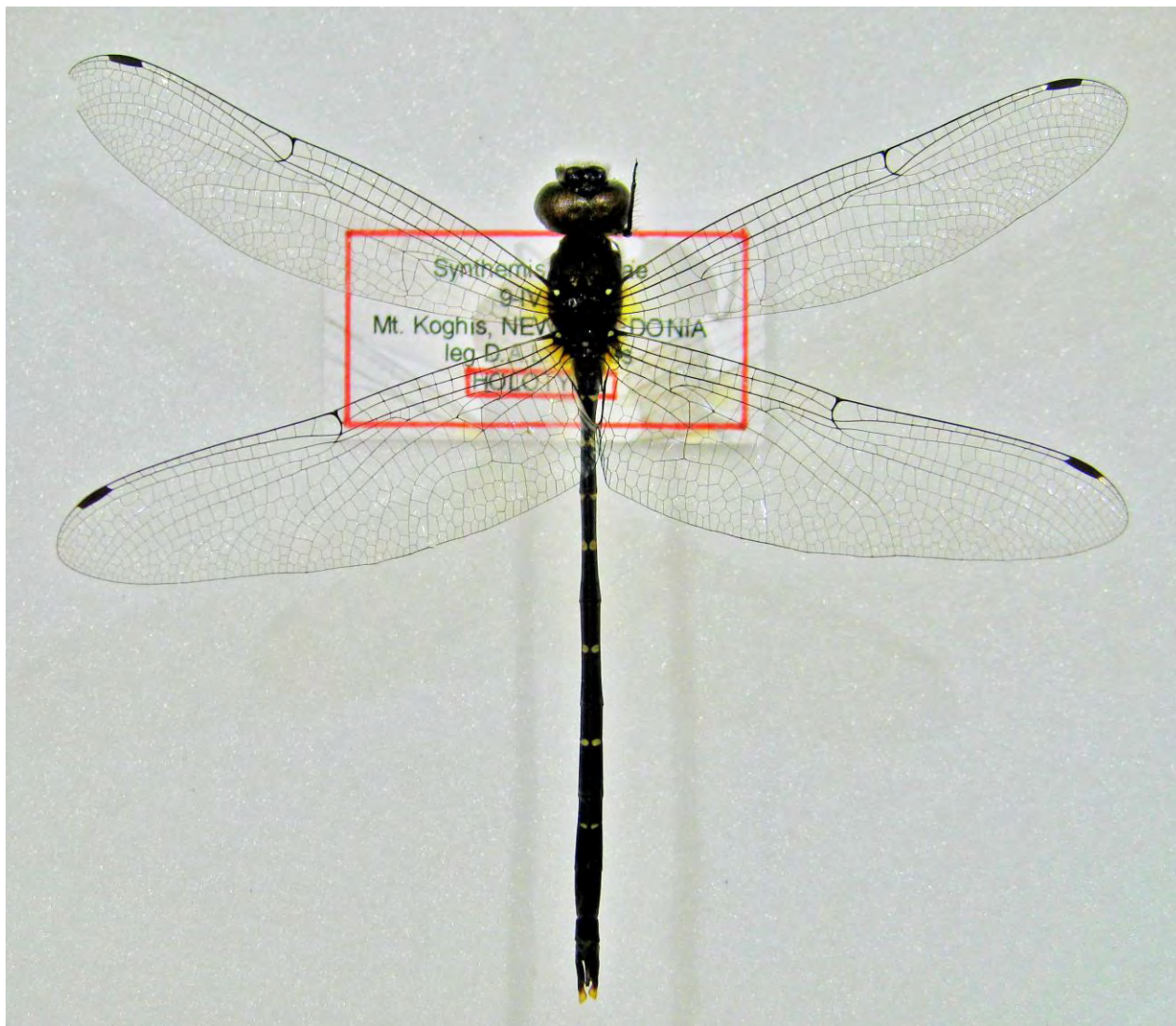
Synthemis pamela Davies, 2002: 234.

Distribution (Fig. 73). Endemic to Grande Terre. It has been described recently from only three localities on, all south of the municipality of Païta (Davies 2002).

Habitat. we assume that its habitats probably range from lowland rivers to streams up to about 1,000 m altitude on Monts Koghis.

biology and behaviour. No information available for this taxon.

Status. DG unsuccessfully searched for *S. pamelae* in the Païta municipality and at La Capture in the Plaine des Lacs (mid February to early March 2011), during the first third of its flight period. At Monts Koghis, Davies (2002) reported it about at 1,000 metres above sea level, in an area where there are no rivers and in lowlands where it is threatened by the rapid urbanization of the Païta and Dumbéa municipalities. Considering its limited distribution and our failure to find it we rank *S. pamelae* as EN.



FigRe 72. *Synthemis pamelae*, holotype male, University Museum of Zoology, Cambridge (E. Turner).

***Synthemis serendipita* Winstanley, 1984**

(Fig. 74)

Synthemis serendipita winstanley, 1984b: 9.

Distribution (Fig. 75). Endemic to Grande Terre. Some females reach a 100 mm wingspan. The species is known only from seven locations in the southern half of the island, and in particular the mountains east of Nouméa.

Habitat. Creeks and streams in mountain forest.

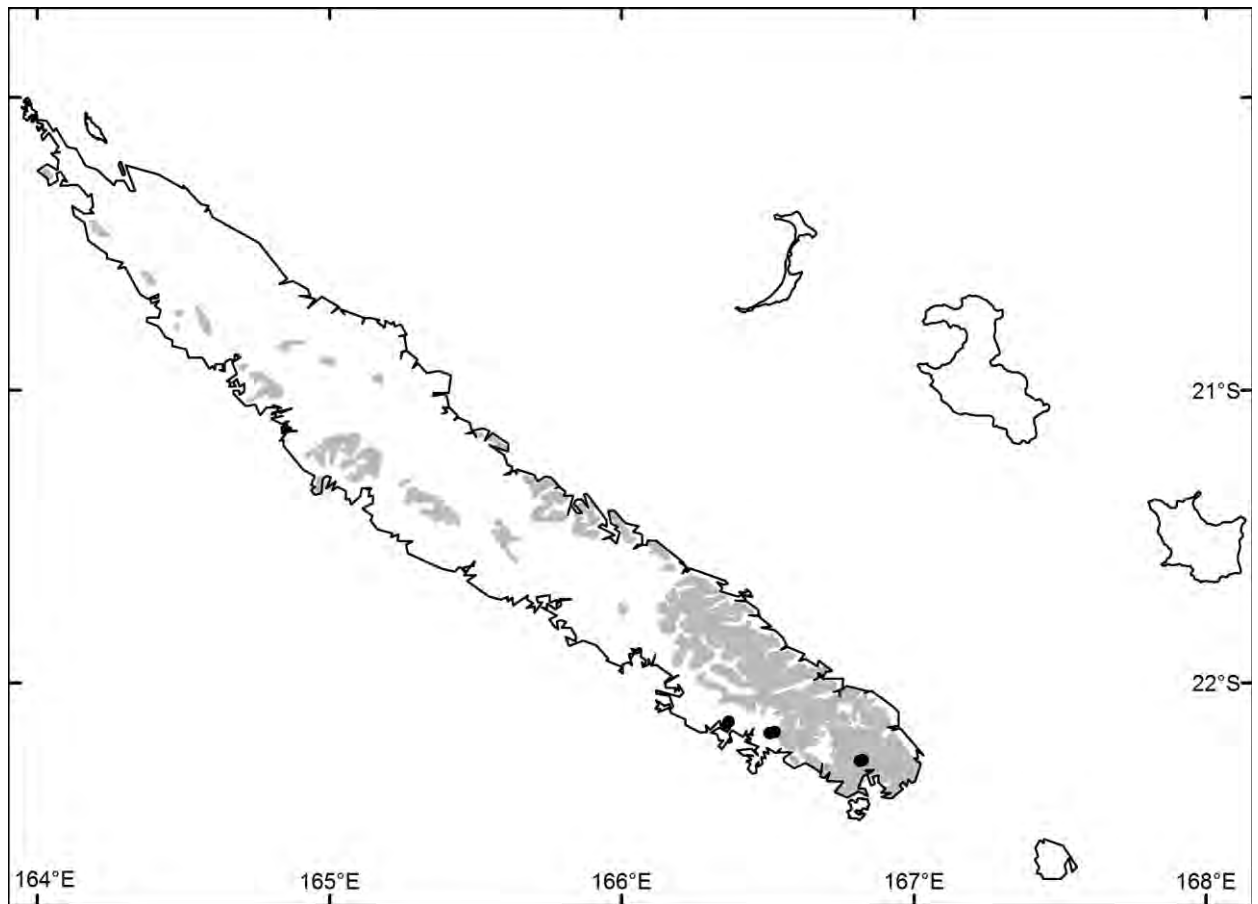


FIGuRe 73. Records of *Synthemis pamelae*.



FIGuRe 74. *Synthemis serendipita*, male.

biology and behaviour. A few exuviae were found on the banks of creeks up to a metre above the water level. This species is not observed before noon at oviposition sites. Because they fly late at night, Davies (2002) compared its behavior with the crepuscular habits of *Gynacantha*. As in *S. miranda*, which is often found with *S. serendipita*, males are territorial. However, females appear to be more selective in their choice of oviposition sites. The males fly quietly over pools until the arrival of females. Mating (three observations) occurs in flight for less than a minute. The female lays her eggs alone (four observations) on rocks covered by a thin layer of water (2–3 mm).

Status. we observed several large *S. serendipita* populations at the sites that we visited. However, due to the small number of localities from which it is known, we rank it as EN.

Comments. At the creek near the Sanatorium at the Col de la Pirogue, other *Synthemis* species visit the oviposition sites throughout the day. In the early morning, *S. fenella* is the first species to arrive at around 07:30 h, then around 10:00–11:00 h this species is replaced by *S. miranda*. At 12:00–12:30 h, the first males of *S. serendipita* appear, driving off males of *S. miranda*.

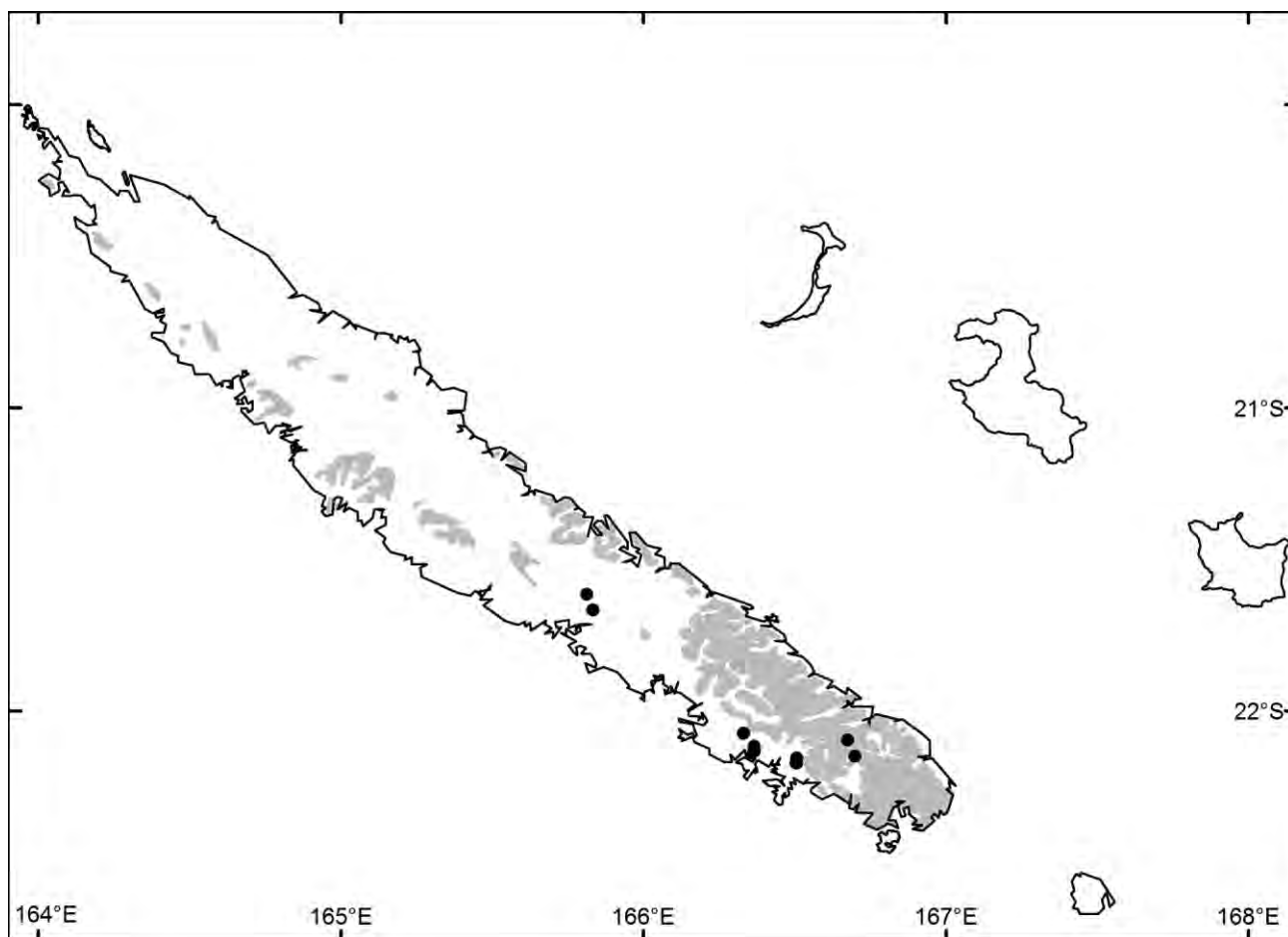


Figure 75. Records of *Synthemis serendipita*.

Family Libellulidae Rambur, 1842

The vast family of Libellulidae is represented in every biogeographic region with the exception of the Antarctic (Kalman *et al.* 2008). It is also the most diversified family in New Caledonia with 12 genera and 18 species (excluding *T. limbata*) representing one third of the New Caledonian Odonata fauna. The large number of libellulid species in New Caledonia, most of which are widespread and none of which are endemic, may be explained by their high vagility and eurytopic habitat tolerance. They prefer standing water in the coastal lowlands, although some species adapt to inland waters including slow flowing streams. Depending on the species, mating takes place in flight or while resting on vegetation. Ovipositing females release their eggs either on contact with the water or above it. Some species flick eggs in water droplets onto rocks and banks just above the water surface using a special scoop at the tip of the abdomen.



Figure 76. *Agrionoptera insignis*: a) male (O. Hébert), b) female, Australia (E. Nielsen).

***Agrionoptera insignis* (Rambur, 1842)**

(Fig. 76)

Libellula insignis Rambur, 1842: 123.

Distribution (Fig. 77). In the Pacific, various subspecies of *A. insignis* are recorded over a large area from New Guinea to Vanuatu (Kimmins 1953). The species is mainly reported from off shore islands like Île des Pins (Ris 1915) and the Loyalty Islands (Ris 1909; Kimmins 1953). According to Davies (2002), it also occurs on Grande Terre, without giving any precise locality he stated: 'scattered colonies varying in different seasons'.

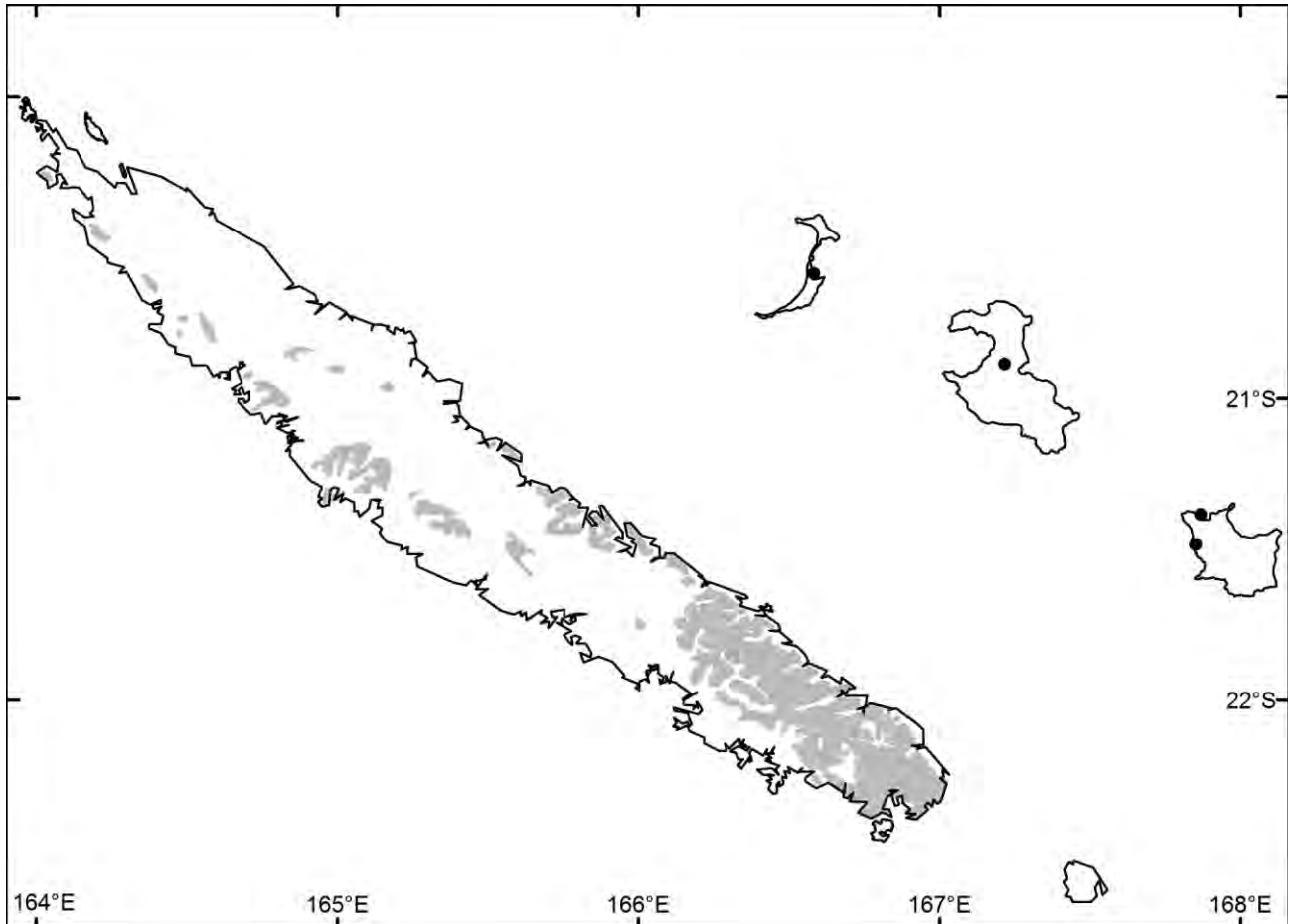


Figure 77. Records of *Agrionoptera insignis*.

Habitat. This species dwells in swamps, ponds and lakes.

biology and behaviour. The larva was illustrated by Theischinger & Hawking (2006), but behavioural information is lacking.

Status. Available data are inadequate to establish its conservation status hence we class it as DD. More investigations on distribution of this species are necessary, but the center of occurrence should be in the northern part of Grande Terre, a region that has not been sufficiently investigated to date.

***Diplacodes bipunctata* (brauer, 1865)**

(Fig. 78)

Libellula bipunctata Brauer, 1865a: 503; *Cordulia novae-zelandiae* Brauer, 1865; *Diplax pacificum* Kirby, 1894; *Sympetrum bipunctatum novaezealandiae* McLachlan, 1894.

Distribution (Fig. 79). A widely distributed species found from East Africa in the west, Japan in the north, Australia and New Zealand in the south and the Pacific islands in the east (Fiji, Vanuatu, Guam, Palau, Micronesia, Marshall

Islands, Northern Marianna Islands) (Tsuda 2000) and even French Polynesia (Paulian 1998). It is widespread in New Caledonia, having been found at more than 20 localities on Grande Terre. Bigot (1985) collected a few individuals in the Dumbéa municipality, in the Plaine des Lacs and on Ouvéa.



FIGURE 78. *Diplacodes bipunctata*: a) male, b) female.

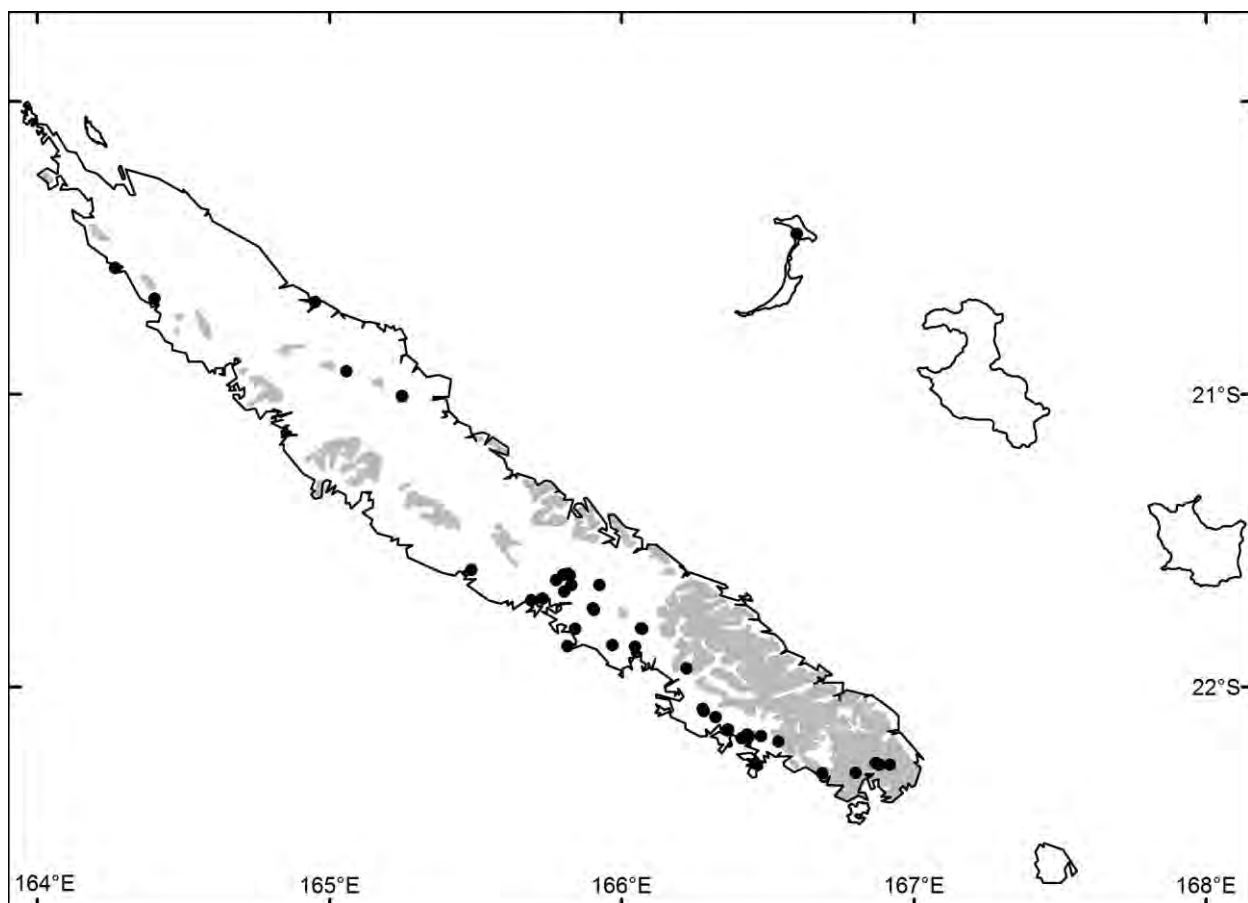


Figure 79. Records of *Diplacodes bipunctata*.

Habitat. *Diplacodes bipunctata* occurs in swamps and ponds in sunny places.

biology and behaviour. The larva was illustrated by Lieftinck (1962). Adults fly extensively over bodies of water, perching frequently.

Status. In view of its wide distribution, *D. bipunctata* does not seem threatened in New Caledonia. we therefore rank it as LC.

***Diplacodes haematodes* (burmeister, 1839)**

(Fig. 80)

Libellula haematodes Burmeister, 1839: 849; *Trithemis rubra* Foerster, 1898; *Trithemis subhyalina* Foerster, 1898.

Distribution (Fig. 81). This species is recorded from Australia, Indonesia, Papua New Guinea and Vanuatu (Tsuda 2000). Reported from Île des Pins without voucher specimens, it occurs widely on Grande Terre, having been found at nearly 70 localities. One specimen from Nouméa is in the ONNC collection and another one, collected in January 2007, is held at the CXMNC collection.

Habitat. *Diplacodes haematodes* occurs in sunny places with standing water or streams with a moderate rate of flow. It tolerates ultramafic soil.

biology and behaviour. The larva was illustrated by Theischinger & Hawking (2006). Exuviae are found not far above the water level, hanging from waterside vegetation. Couples oviposit in tandem, the female touching the water with her abdomen up to twenty times.

Status. In view of its wide distribution, *D. haematodes* does not appear threatened in New Caledonia. we rank it LC.



Figure 80. *Diplacodes haematodes*, male.

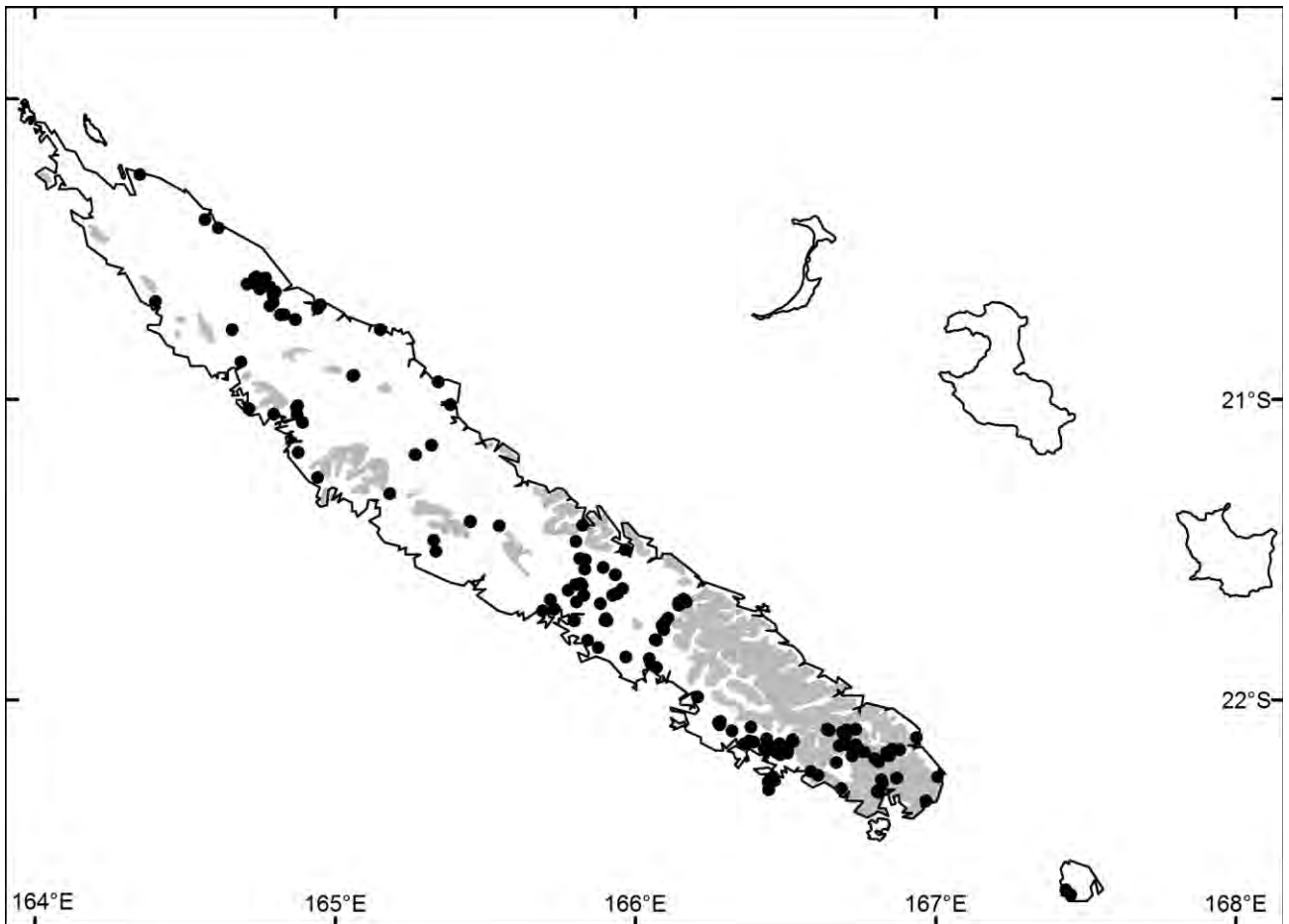


Figure 81. Records of *Diplacodes haematodes*.



FIGURE 82. *Diplacodes trivialis*: a) male, Australia (E. Nielsen), b) female, Indonesia (E. Nielsen).

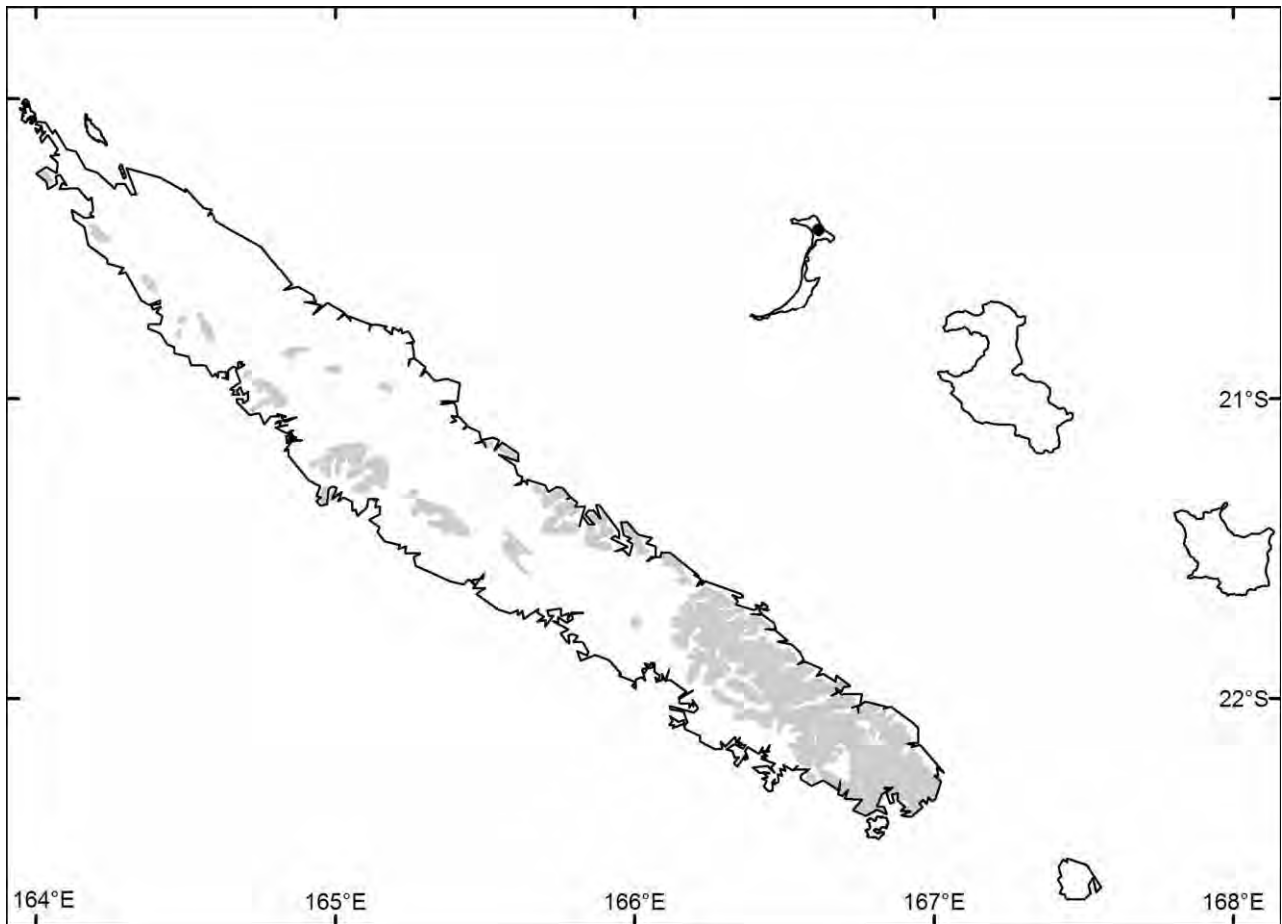


Figure 83. Records of *Diplacodes trivialis*.

***Diplacodes trivialis* (Rambur, 1842)**

(Fig. 82)

Libellula trivialis Rambur, 1842: 115; *Libellula phalerata* Uhler, 1858; *Diplacodes remota* Ris, 1911.

Distribution (Fig. 83). This species is widely distributed from the Seychelles and India, to Japan, Australia and as far as Fiji and Vanuatu (Tsuda 2000). we recorded several individuals above a shallow pond in a sand pit on Ouvéa, on the 26th August 2011.

Habitats. Temporary waters, swamps and ponds (Theischinger & Hawking 2006).

biology and behaviour. Its biology is unknown, but *D. trivialis* is known to be migratory (Fraser 1936).

Status. This record might have been incidental, representing vagrant individuals from Vanuatu; we therefore do not provide any threat evaluation for this species (DD).

***Lathrecista asiatica festa* (Selys-Longchamps, 1879)**

(Fig. 84)

Libellula asiatica Fabricius, 1790; *Agrionoptera festa* Selys-Longchamps, 1879: 300; *Agrionoptera simulans* Selys-Longchamps, 1879; *Lathrecista terminalis* Kirby, 1889.

Distribution (Fig. 85). According to Tsuda (2000), *Lathrecista asiatica* is distributed from the Oriental region to New Guinea and Northern Australia. The species is known from Aru Islands, Tanimbar Island, New Guinea, Torres Strait Islands, Solomon Islands, North Australia and New Caledonia (Davies 2002; Michalski 2012; Marinov &

Pikacha 2013). In New Caledonia, it is known from a single location in northern New Caledonia (Yiambi, Lieftink 1975), although Davies (2002) wrote: 'colonies here and there varying with the season'.



Figure 84. *Lathrecista asiatica*, male (J. Barrault).

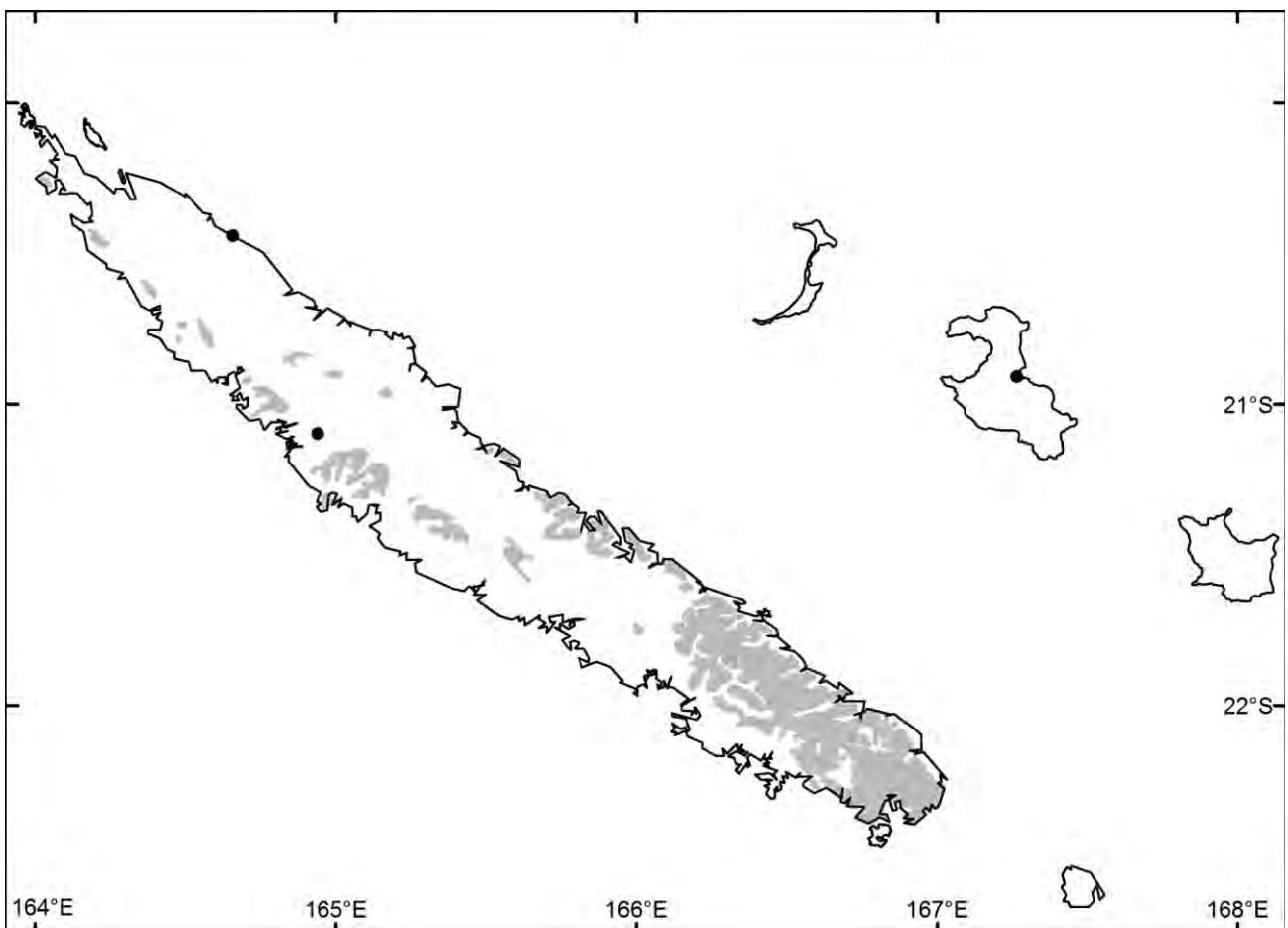


Figure 85. Records of *Lathrecista asiatica*.

Habitat. This species dwells in standing and slowly flowing water bodies in open areas.

biology and behaviour. The larva was provisionally illustrated by Theischinger & Hawking (2006). It will be described elsewhere (A. Orr pers. comm.).

Status. we lack information about this taxon in New Caledonia (DD).

***Macrodiplax cora* (Kaup in brauer, 1867)**

(Fig. 86)

Diplax cora Kaup in Brauer, 1867: 20; *Libellula lycoris* Selys-Longchamps, 1872; *Libellula nigrilabris* Selys-Longchamps, 1872; *Urothemis nigrilabris* Selys-Longchamps, 1878; *Urothemis vittata* Kirby, 1893.



Figure 86. *Macrodiplax cora*, male.

Distribution (Fig. 87). This species is recorded from tropical areas in the Old world (from East Africa in the west to Japan in the north, Australasia and western Pacific Islands in the east (Fiji, Guam, Palau and Samoa) (Tsuda 2000). In New Caledonia, it is known from seven localities. winstanley & Davies (1983) recorded it from the Houaïlou River and from the municipality of Ouégoa, whereas Bigot (1985) collected several specimens on coastal roads in the Dumbéa municipality, in Prony and in Touaourou. Two specimens collected in Nouméa are conserved at the ONNC collection.

Habitat. *Macrodiplax cora* colonises coastal swamps, including temporary or brackish waters as well as low-land ponds in sunny places.

biology and behaviour. This migratory species is mostly observed over coastal water bodies. Its larva was illustrated by Liefertinck (1962).

Status. Reproduction of *M. cora* in New Caledonia is not confirmed. we rank this species as DD, awaiting more information about its distribution.

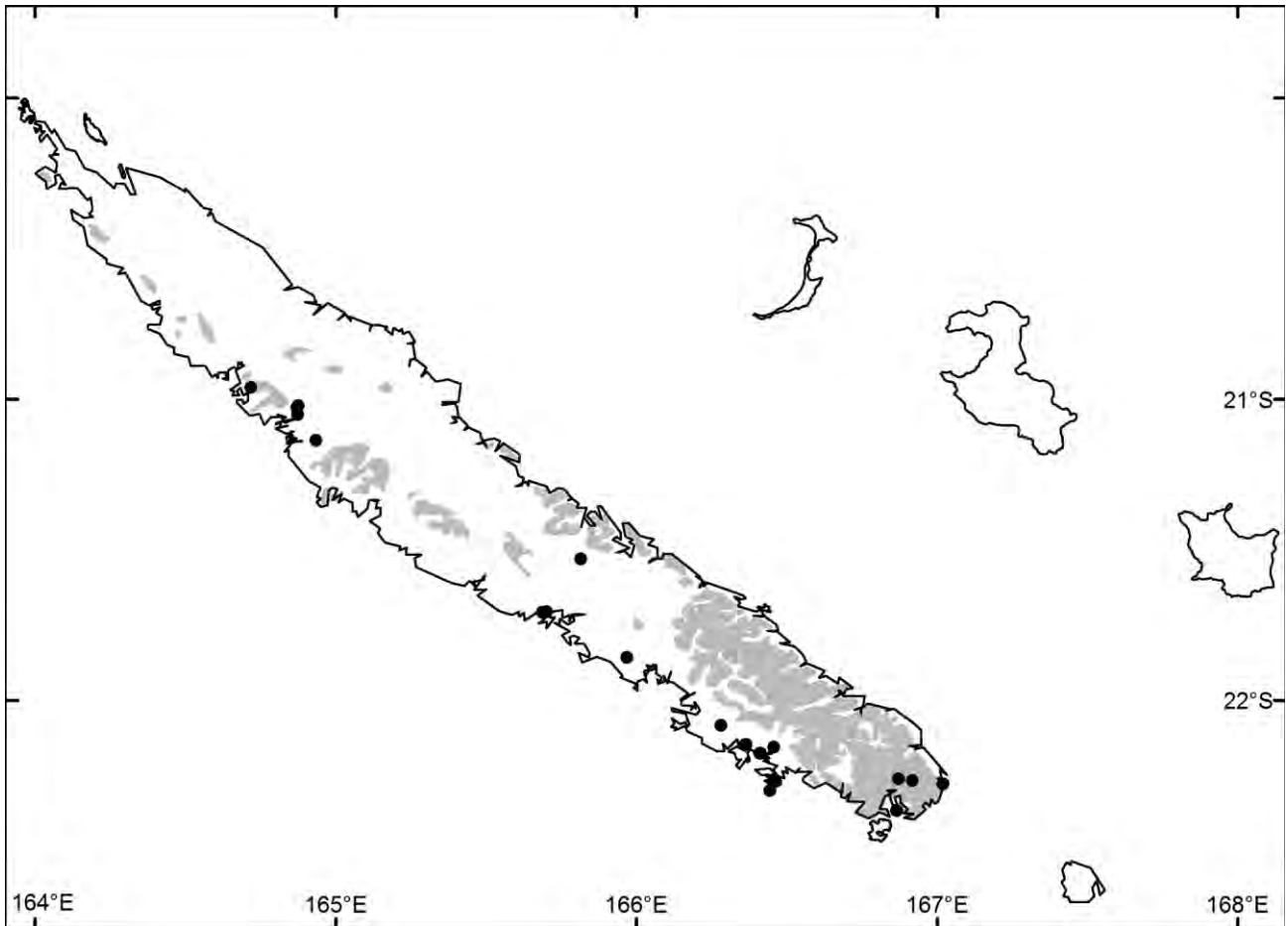


Figure 87. Records of *Macrodiplax cora*.

***Neurothemis stigmatizans* (Fabricius, 1775)**

(Fig. 88)

Libellula stigmatizans Fabricius, 1775: 421; *Libellula oculata* Fabricius, 1775; *Libellula elegans* Guérin-Méneville, 1832; *Libellula manadensis* Boisduval, 1835; *Neurothemis diplax* Brauer, 1867; *Neurothemis innominata* Brauer, 1867; *Neurothemis pseudosphronia* Brauer, 1867; *Neurothemis unicolor* Selys-Longchamps, 1868.

Distribution. This species is known from Indonesia, Papua New Guinea, north eastern Australia, the Solomon Islands and Vanuatu (Tsuda 2000). In New Caledonia, one specimen was caught in January 1984, subsequently labelled ‘Nlle Calédonie’ and deposited in the collections of the Musée des Confluences in Lyon (Grand 2004a). we consider this species as vagrant for New Caledonia and did not map distribution. Its subspecies affiliation has not yet been established. *Neurothemis stigmatizans bramina* Guérin-Méneville in Lesson, 1830 is the only subspecies known in the Pacific. It is known from New Britain, the Solomon Islands and Vanuatu (Michalski 2012).

Habitat. This species occurs in various standing and slowly flowing water habitats.

biology and behaviour. Lieftinck (1962) illustrated the larva of *N. stigmatizans bramina* from New Guinea.

Status. This species appears to be a vagrant in New Caledonia, we therefore suggest ranking it as DD.



Figure 88. *Neurothemis stigmatizans*, male, Vanuatu (M. Marinov).

***Orthetrum caledonicum* (brauer, 1865)**

(Fig. 89)

Libellula caledonicum Brauer, 1865a: 505; *Libellula coelestis* Selys-Longchamps, 1849 (nomen nudum); *Libellula braminae* Fabricius, 1798.

Distribution (Fig. 90). This species is known from Australia, Indonesia, Papua New Guinea and Vanuatu (Tsuda 2000). In New Caledonia, it is recorded from more 70 localities on Grande Terre, Île des Pins and Ouvéa, often in large populations. Bigot (1985) collected this species in Dumbéa municipality, in the Baie de Prony, and in the Plaine des Lacs. One specimen collected in Nouméa is held at the ONNC collection and others, collected in 2001 and 2008 in La Foa (Pocquereux valley), are held in the CXMNC collection.

Habitat. This species dwells in standing or slowly flowing water in sunny places. It also occurs on ultramafic soil.

biology and behaviour. we found exuviae of this species, which seems to emerge year-round, low in the vegetation on the banks. Males defend a small territory in which mating occurs. Mating lasts 2–3 minutes, on the ground or in low vegetation. The female lays her eggs with the perched or hovering male guarding nearby, even in the absence of other males. The female releases her eggs on contact with water.

Status. we rank *O. caledonicum* as LC.



FIGURE 89. *Orthetrum caledonicum*: a) male, b) female.

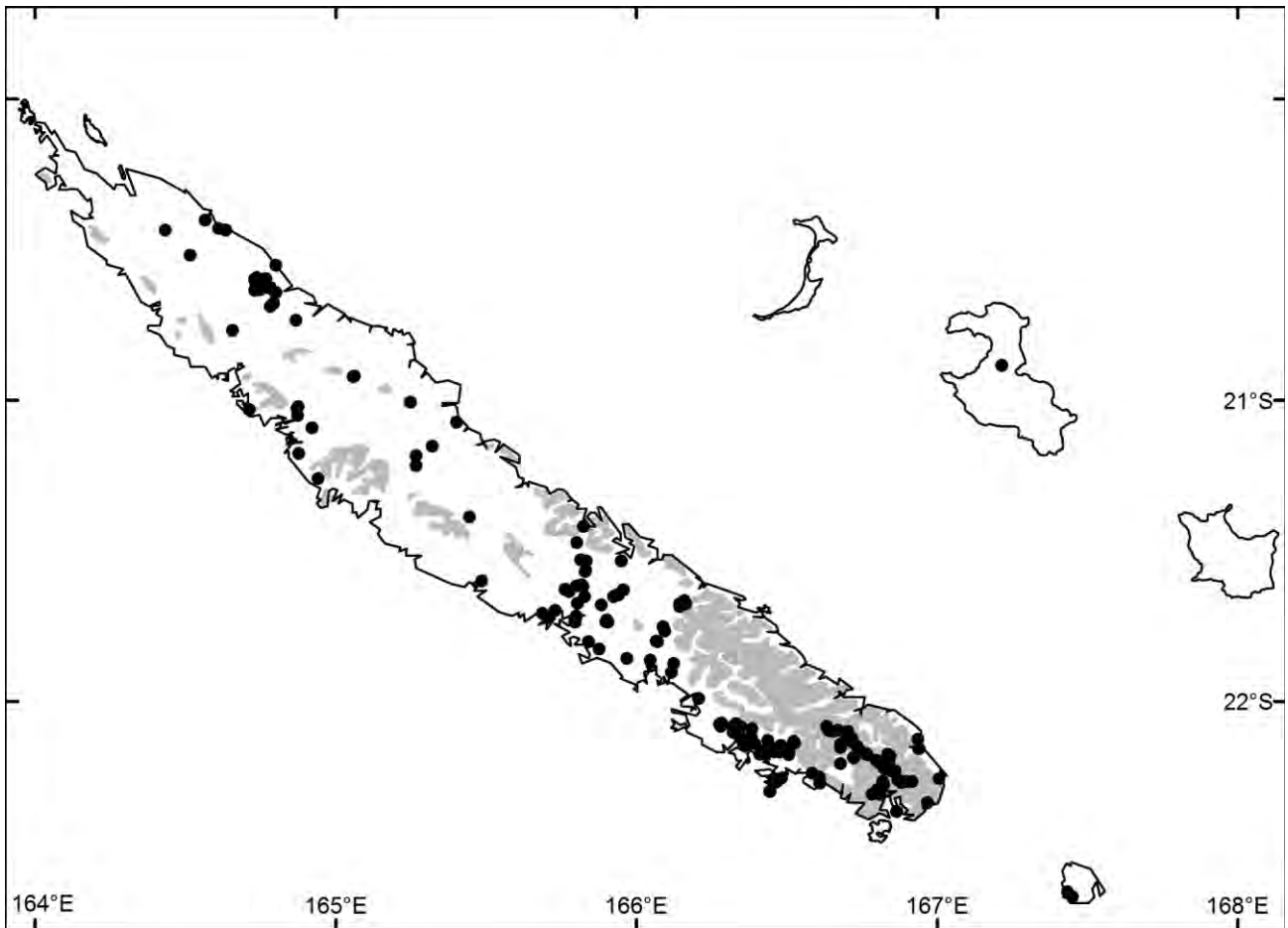


Figure 90. Records of *Orthetrum caledonicum*.

Orthetrum serapia/sabina

Davies (2002) reported *O. sabina* (Drury, 1773) for New Caledonia and wrote that it was common. However, we never found this species during our field work. All specimens that we found were from the closely related *O. serapia* watson, 1984. Therefore, Davies (2002) might have misidentified *O. serapia* as *O. sabina*. when we published our key to New Caledonia and wallis & Futuna (Grand *et al.* 2014), we assumed that only *O. sabina* occurred on these archipelagos. we also found *O. serapia* and not *O. sabina* on wallis and Futuna (authors' unpublished data). To correct the error, we compare the diagnostic features of both species in Figure 91.

Distribution (Fig. 92). *Orthetrum sabina* has a wide range within the Afrotropical, Oriental, Australasian and Oceanic regions (Tsuda 2000). It even reaches in the north the southern borders of the Palearctic region, from Tunisia in the west to Japan in the east (Tsuda 2000). *Orthetrum serapia* is distributed wide across the Pacific reaching Australia to the west and Tonga to east (Marinov & waqa-Sakiti 2013). Both species are present in the Northern Territory and north east of Australia (Theischinger & Hawking 2006), therefore their coexistence in New Caledonia is not to be excluded.

However, in a recently published study on the Odonata fauna of Vanuatu Marinov *et al.* (2019) reported *O. serapia* for the islands of Efate and Malekula but not for Aneityum and suggested that the southern limit of the species distribution within the Pacific lays along 18–19°S which is just at the northern most end of Grande Terre of New Caledonia. In Australia (Theischinger & Endersby 2009), the species reaches even further south to around 22°.

Habitat. Both species occur in sunny places at standing and running water and tolerates moderately salinity.

biology and behaviour. The larva of *O. sabina* was illustrated by Lieftinck (1962). Its habits are similar to *O. caledonicum*.

Status. Due to the lack of information on we rank these species DD.



Figure 91. Comparison between: a) *Orthetrum sabina*, female, Malaysia (E. Nielsen), and b) *O. serapia*, female, Futuna Island (J. Theuerkauf). Note the difference in the pattern on the dorsum of S4–6.

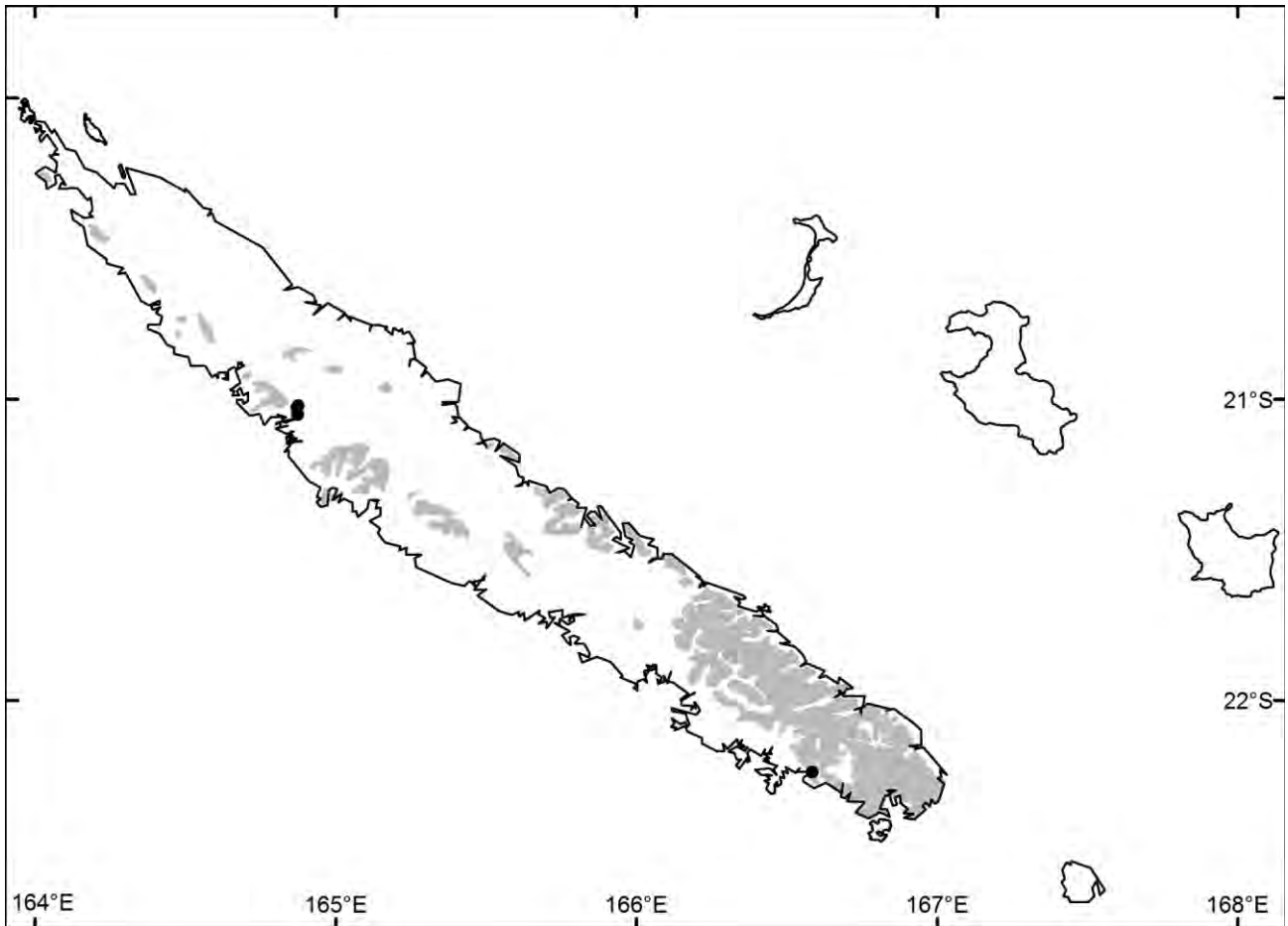


Figure 92. Records of *Orthetrum sabina/serapia*.

***Orthetrum villosovittatum* (brauer, 1868)**

(Fig. 93)

Libellula villosovittatum Brauer, 1868: 167; *Orthetrum bismarckianum* Ris, 1898; *Orthetrum fenicheli* Foerster, 1898; *Orthetrum parvulum* Foerster, 1903.

Distribution. This species is widespread in eastern Indonesia, Papua New Guinea, the Solomon Islands and New Caledonia (Tsuda 2000). However, no locality is known from New Caledonia despite Davies (2002) reporting it to be 'quite common'. Therefore, we did not map its distribution.

Habitat. According to Theischinger & Hawking (2006), this species occurs in diverse standing and slowly running waters, including swamp and temporary habitats.

biology and behaviour. Its larva was illustrated by Hawking (1986) and its habits are similar to other species of *Orthetrum*.

Status. Due to the lack of information on its distribution, we rank this species DD.

***Pantala flavescens* (Fabricius, 1798)**

(Fig. 94)

Libellula flavescens Fabricius, 1798: 285; *Libellula viridula* Beauvois, 1805; *Libellula terminalis* Burmeister, 1839; *Libellula analis* Burmeister, 1839; *Orthetrum mathewi* Singh & Bajjal, 1955; *Sympetrum tandicola* Singh, 1955.



FIGURE 93. *Orthetrum villosovittatum*, male, Solomon Islands (M. Marinov).

Distribution (Fig. 95). Expanding its range northward in the recent years, this pantropical species reached Canada (Pilon & Lagace 1998), eastern Siberia north of Vladivostok (D. Grand, unpubl. data) and the Balkans (Ober 2008). In New Caledonia, it is recorded from 40 localities and Bigot (1985) reports it from Ouvéa. Some specimens, collected in 1999 in the Bourail municipality (Gouaro) and in 2003 in La Foa (Pocquereux valley), are preserved in the CXMNC collection.

Habitat. *Pantala flavescens* is found in a wide range of mostly sunny habitats, including coastal swamps, temporary pools, ponds and lakes, as well as slow open sections of rivers, streams and pools in torrents. It tolerates brackish water.

biology and behaviour. Its larva, illustrated by Lieftinck (1962), lives in diverse habitats, including those lacking aquatic vegetation and development is extremely rapid (Corbet 1999: 218). Exuviae are found on any potential perch that emerges from the water. This highly migratory species is able to cross stretches of ocean of several hundred kilometres. Adults, which spend most of the day airborne, can be observed in urban areas, at higher altitudes or in forest clearings, typically flying comparably high and sometimes forming vast feeding swarms. Males are moderately territorial and mating takes place in flight at a height of 2–3 m and lasts about a minute. The female oviposits alone, often at several well-separated sites, rapidly touching the water surface about a dozen times with the tip of her abdomen during each bout (Grand 2004b).

Status. without known threats, *P. flavescens* is ranked LC.



Figure 94. *Pantala flavescens*, male.

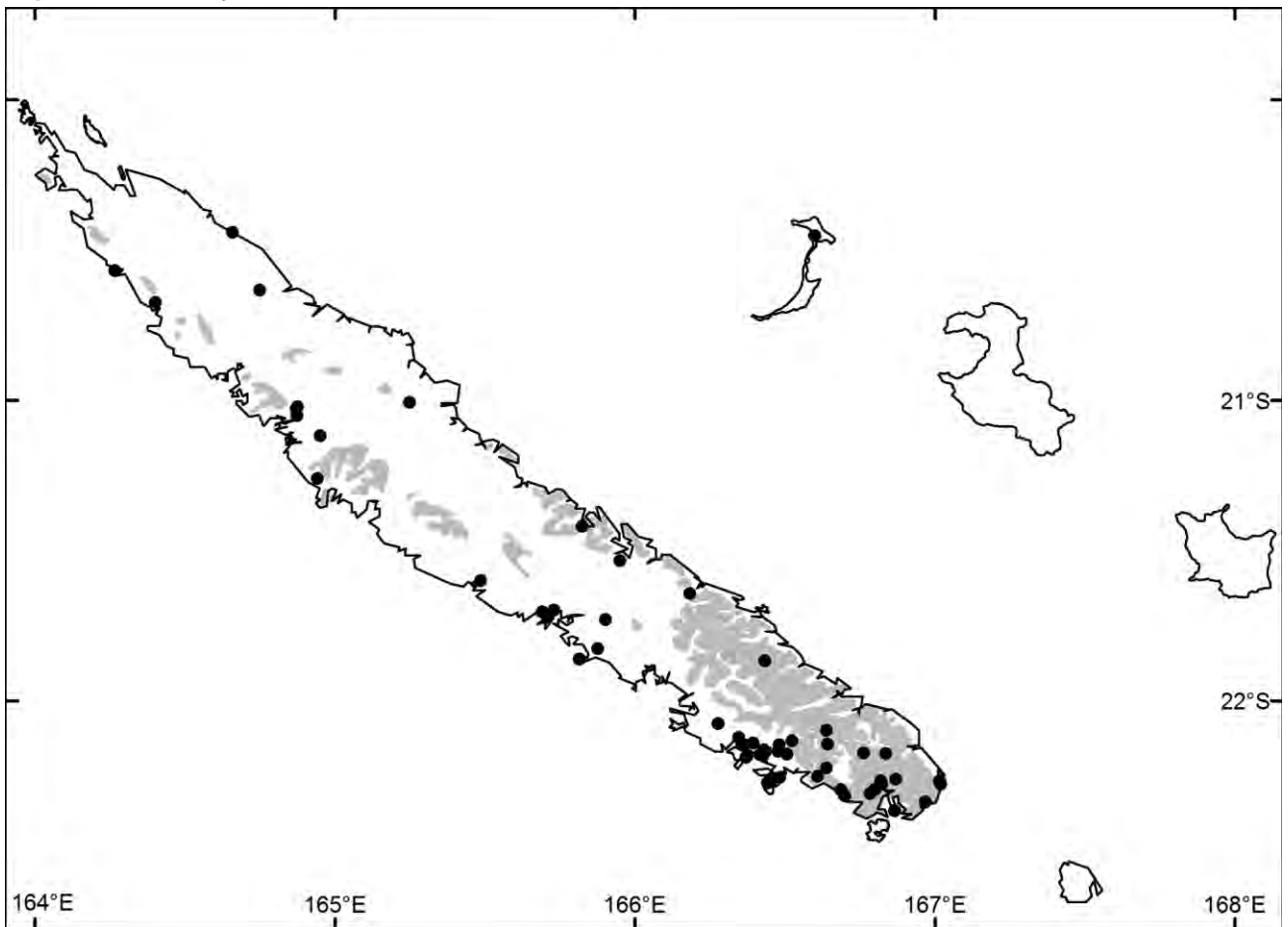


Figure 95. Records of *Pantala flavescens*.

***Rhyothemis graphiptera* (Rambur, 1842)**

(Fig. 96)

Libellula graphiptera Rambur, 1842: 45.

Distribution (Fig. 97). This species inhabits eastern Indonesia, Papua New Guinea, Australia (Tsuda 2000) and New Caledonia where it is recorded at a dozen localities all over Grande Terre. Some specimens collected in 2001 in La Foa (Pocquereux valley) and in 2007 in the Poya municipality (Beaupré) are preserved in the CXMNC collection.

Habitat. It occurs in swamps, ponds and calm sections of watercourses. It avoids ultramafic soil.

biology and behaviour. The larva was briefly illustrated by Theischinger and Hawking (2006). Males are territorial, perching on, for example, a dominant rush above the water and driving away all dragonflies passing too close to them.

Status. *Ryothemis gaphiptera* has a relatively wide range in New Caledonia, but is rarely abundant. we therefore suggest ranking it NT.



Figure 96. *Rhyothemis graphiptera*, male.

***Rhyothemis phyllis apicalis* Kirby, 1889**

(Fig. 98)

Libellula phyllis Sulzer, 1776; *Rhyothemis snelleni* Selys-Longchamps, 1878; *Rhyothemis apicalis* Kirby, 1889: 319.

Distribution (Fig. 99). Regional endemic subspecies. *Ryothemis phyllis*, which includes about a dozen subspecies, is widespread in south-east Asia, north-eastern Australia and the western Pacific Islands (Tsuda 2000). The subspecies *R. phyllis apicalis* is endemic to Vanuatu and New Caledonia where it is recorded from more than 25 localities, in sometimes large populations. One specimen from Nouméa is preserved in the ONNC collection and others collected in 1997 in the municipality of La Foa (Pocquereux valley) and in 2007 in the municipality of Poya (Beaupré) are deposited in the CXMNC collection.

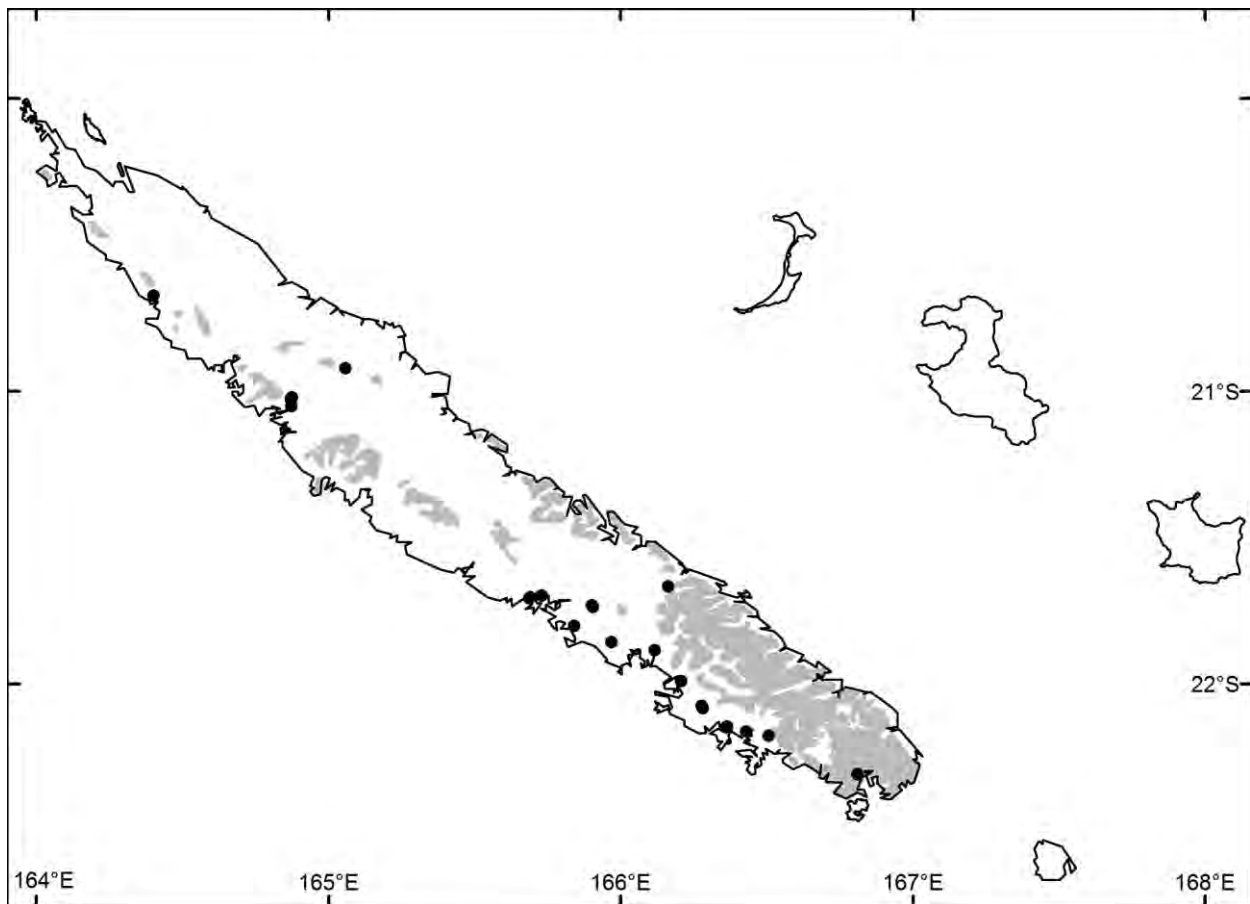


Figure 97. Records of *Rhyothemis graphiptera*.

Habitat. This species is encountered in about the same habitats as *R. graphiptera* and, like this species, avoids ultramafic soil.

biology and behaviour. This species does not seem particularly territorial. Males seek females flying along banks at the edge of the water. Mating takes place on low vegetation and lasts a few minutes, then the female lays her eggs unaccompanied in areas of dense aquatic vegetation. During a rapid and frenetic flight, she releases her eggs, touching the surface of the water several times.

Status. *Ryothemis phyllis apicalis* does not appear threatened, we rank it as LC.

***Tholymis tillarga* (Fabricius, 1798)**

(Fig. 100)

Libellula tillarga Fabricius, 1798: 285; *Tholymis paratillarga* Singh & Baijal, 1954.

Distribution (Fig. 101). This species has a wide global distribution, being recorded from the Afrotropical and Oriental regions (including Japan), northeastern Australia and various Pacific islands (Tsuda 2000). In New Caledonia, it has been recorded from more than 15 localities. winstanley & Davies (1983) records it from the Houailou River and from the municipality of Ouégoa and specimens collected in 2001 and 2002 in La Foa (Pocquereux valley) are kept in the CXMNC collection.

Habitat. It occurs in swamps, ponds and lakes, including forests and very calm parts of running water habitats. It avoids ultramafic soil.

biology and behaviour. Its larva is illustrated by Lieftinck (1962) and we found exuviae in various parts of Grande Terre. Migratory and coloniser, *T. tillarga* flies mostly toward dusk, making its observation difficult, but the white pruinescence of the male wings appears luminous at twilight. In cloudy weather, it can fly as early as 14:30–15:00. Often numerous, males patrol along banks of water bodies. They frequently inspect the banks by

hovering at fixed points, looking for females laying their eggs in inconspicuous places along the banks. Females oviposit by touching the water surface or floating plants debris (Miller & Miller 1985; Grand 2004b). This species flies even in light rain.



FIGURE 98. *Rhyothemis phyllis apicalis*: a) male, b) female.

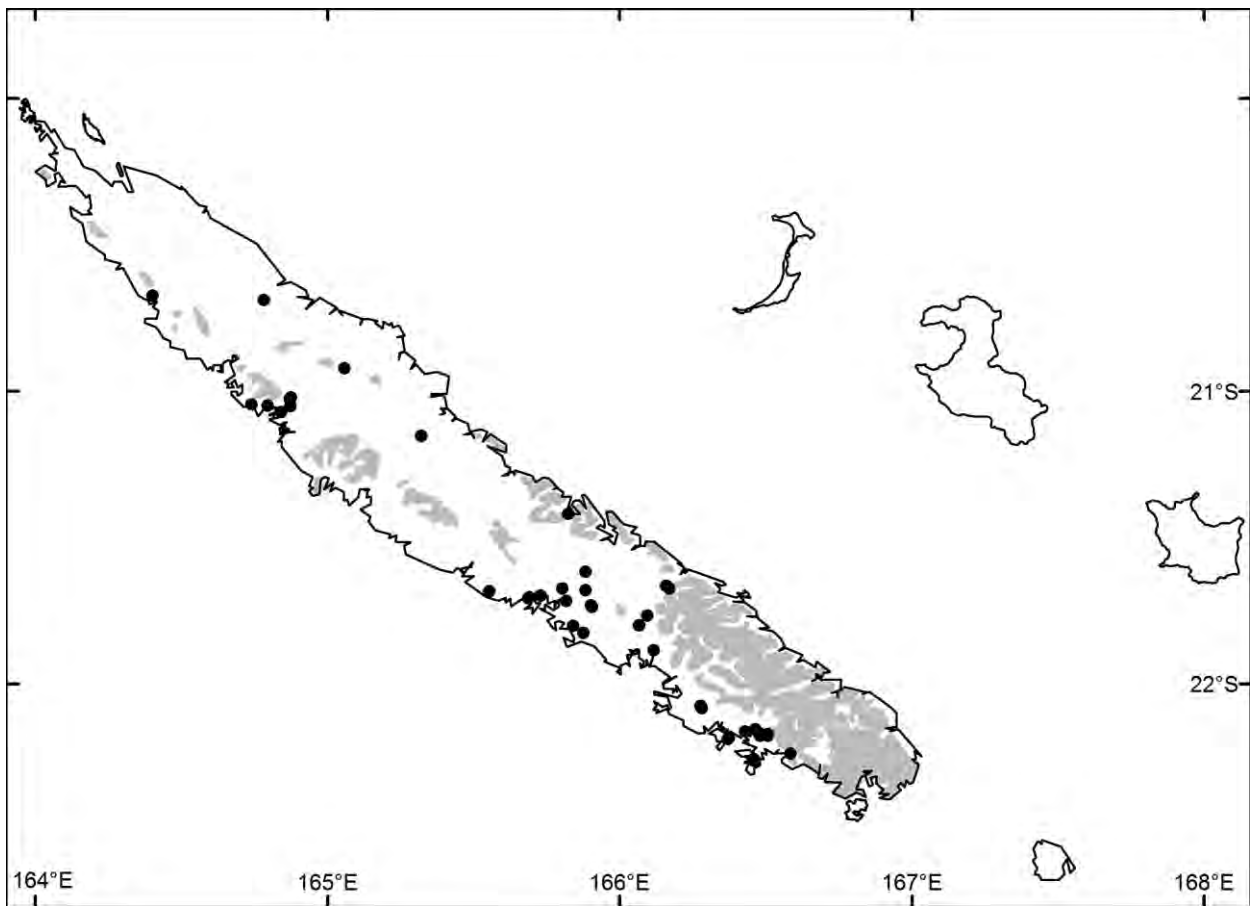


Figure 99. Records of *Rhyothemis phyllis apicalis*.



Figure 100. *Tholymis tillarga*, male.

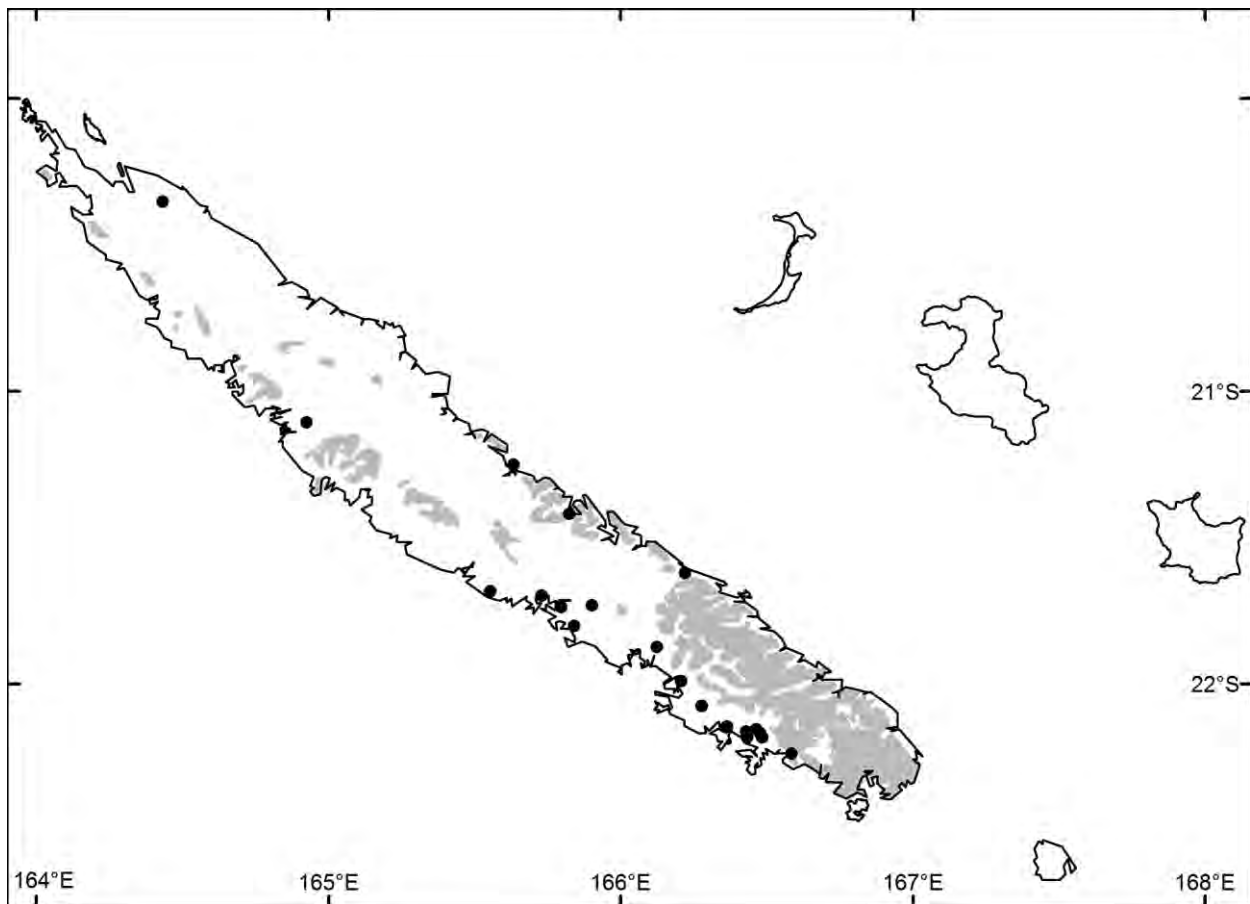


Figure 101. Records of *Tholymis tillarga*.

Status. Because of its crepuscular habits, *T. tillarga* is easy to miss, but it is much more common than records suggest. we rank it NT.

***Tramea liberata* Lieftinck, 1949**

(photo not available)

Tramea liberata Lieftinck, 1949: 371; *Trapezostigma liberata* watson, 1967.

Distribution (Fig. 102). This species is widespread from Papua New Guinea to the Solomon Islands and New Caledonia (Tsuda 2000), where it is recorded from a few localities throughout Grande Terre.

Habitat. This species occurs in swamps, ponds and lakes.

biology and behaviour. Not yet described.

Status. Because there is still some debate about its status in New Caledonia, we were unable to assess its conservation status (DD).

***Tramea loewii* Kaup in brauer, 1866**

(Fig. 103)

Tramea löwii Brauer, 1866: 563; *Tramea tillyardi* Lieftinck, 1942.

Distribution (Fig. 104). This species' range covers eastern Indonesia, Papua New Guinea, Australia, New Zealand and New Caledonia (Tsuda 2000). In New Caledonia, the species is known from fewer than 10 localities, but at high population densities, especially in the far south.

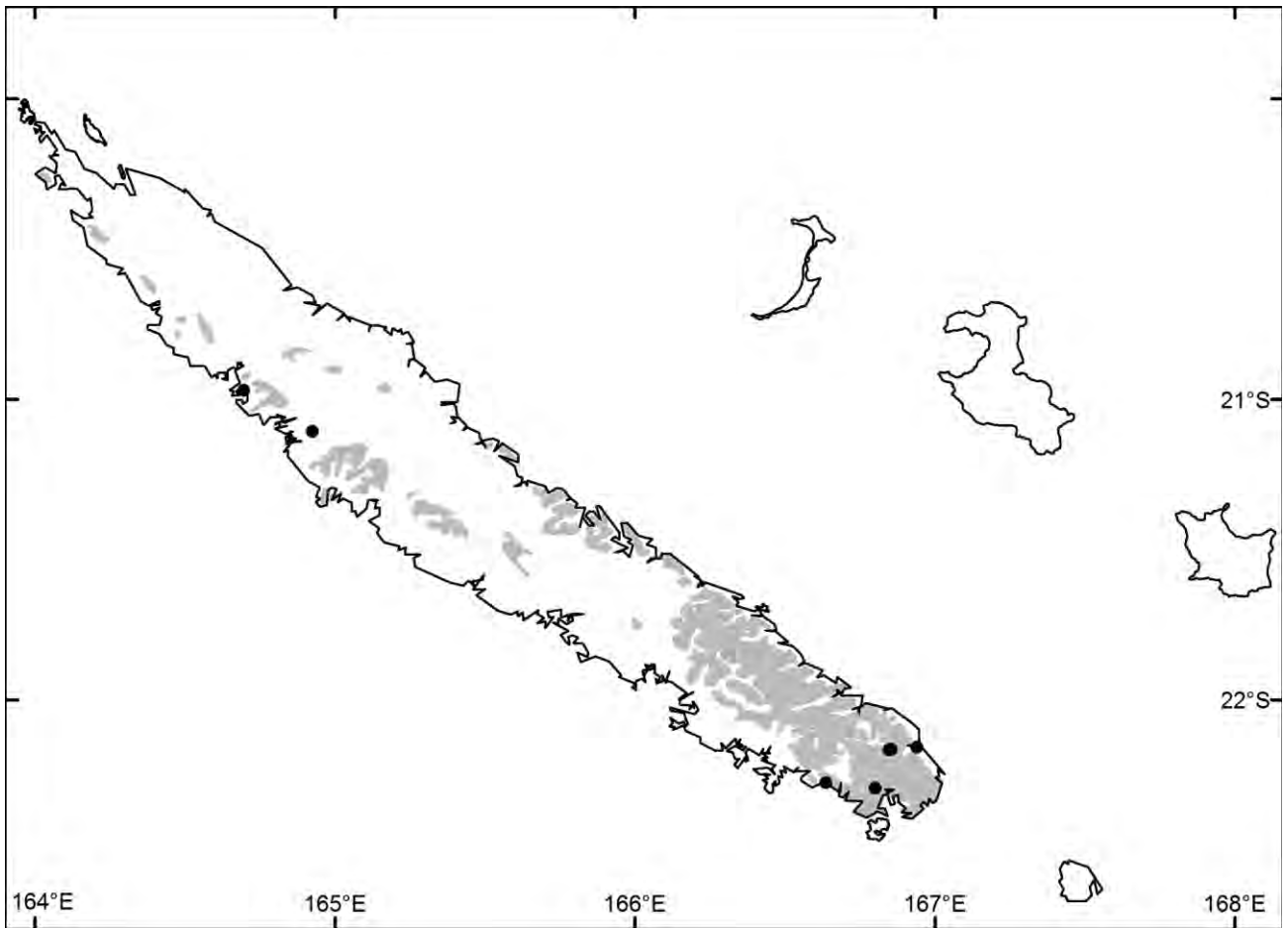


Figure 102. Records of *Tramea liberata*.



Figure 103. *Tramea loewii*, male.

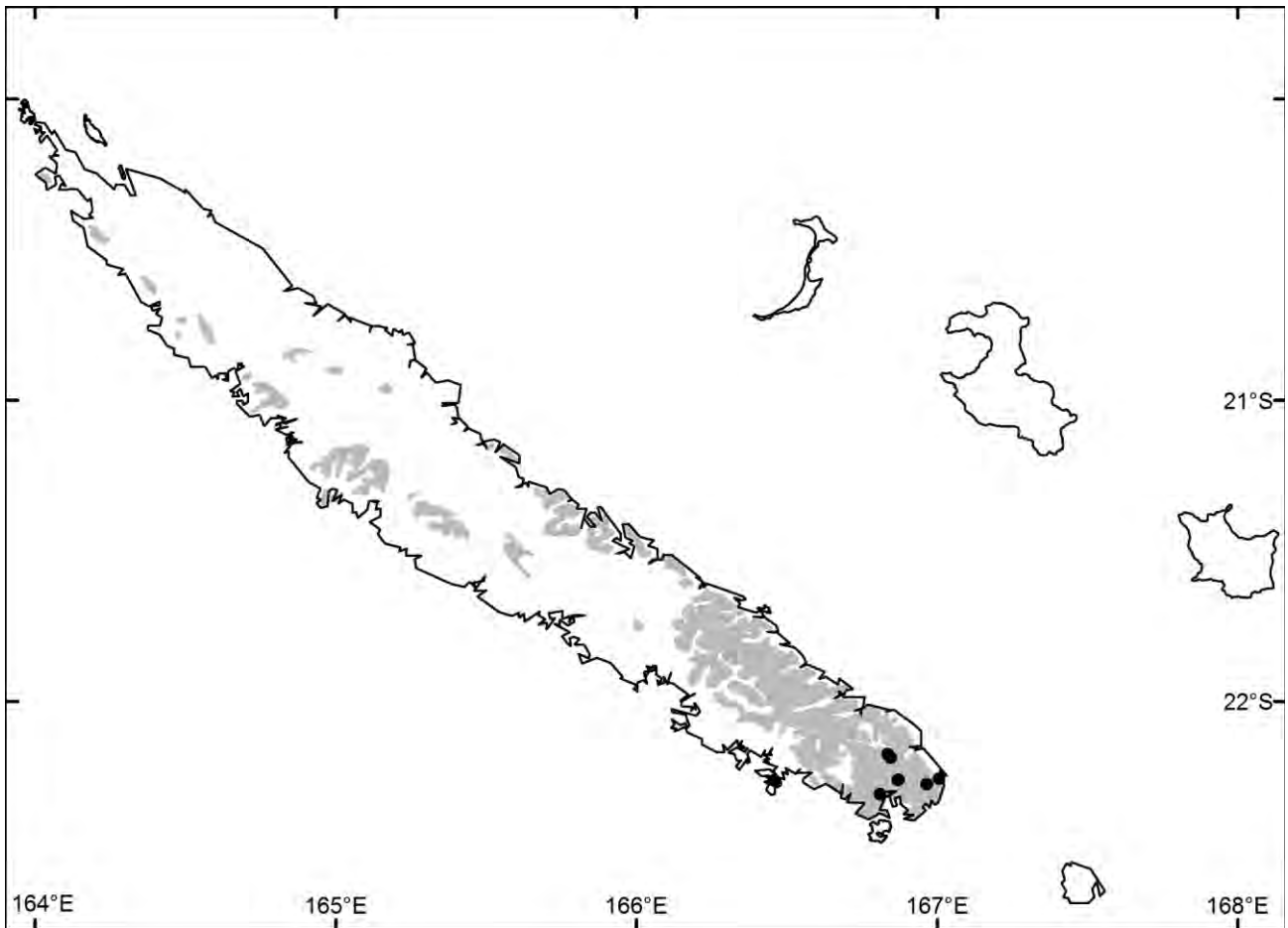


Figure 104. Records of *Tramea loewii*.

Habitat. It occurs in swamps, ponds and lakes on ultramafic soils.

biology and behaviour. Its larvae were illustrated by Theischinger & Hawking (2006). Adults patrol mostly standing water bodies where they move around widely with infrequent stops on vegetation. Couples fly in tandem above water and the method of oviposition is similar to that described for *T. limbata* (Corbet 1999). This is a rather unusual behaviour. The tandem pair flies over the water and at selected places, the male releases the female who oviposits by bringing the tip of her abdomen into contact with the water surface, then the tandem reforms and the pair proceed to the next site, and so on.

Status. *Tramea loewii* is restricted in distribution, being found only in the southern part of Grande Terre. Due to increasing nickel mining in this region, we consider this species as vulnerable in New Caledonia (VU).

***Tramea transmarina intersecta* Lieftinck, 1975**

(Fig. 105)

Tramea limbata Ris, 1913; *Tramea limbata* Desjardins, 1832; *Trapezostigma limbata* Desjardins, 1832; *Tramea samoensis* Brauer, 1867; *Trapezostigma euryale* Selys-Longchamps, 1878; *Tramea transmarina intersecta* Lieftinck, 1975: 162.

Distribution (Fig. 106). Regional endemic subspecies. *T. transmarina* has several subspecies in southeast Asia, including Japan and also numerous islands in the Pacific (Tsuda 2000). *Tramea transmarina intersecta* is known from Vanuatu (Lieftinck 1976; Tsuda 2000) and from New Caledonia where it has recorded from more than 20 localities. Bigot (1985) caught numerous specimens in Baie de Prony. Finally, several specimens from Nouméa are held at the ONNC collection and one specimen collected in 1999 in La Foa (Pocquereux valley) is preserved in the CXMNC collection.



Figure 105. *Tramea transmarina intersecta*, male.

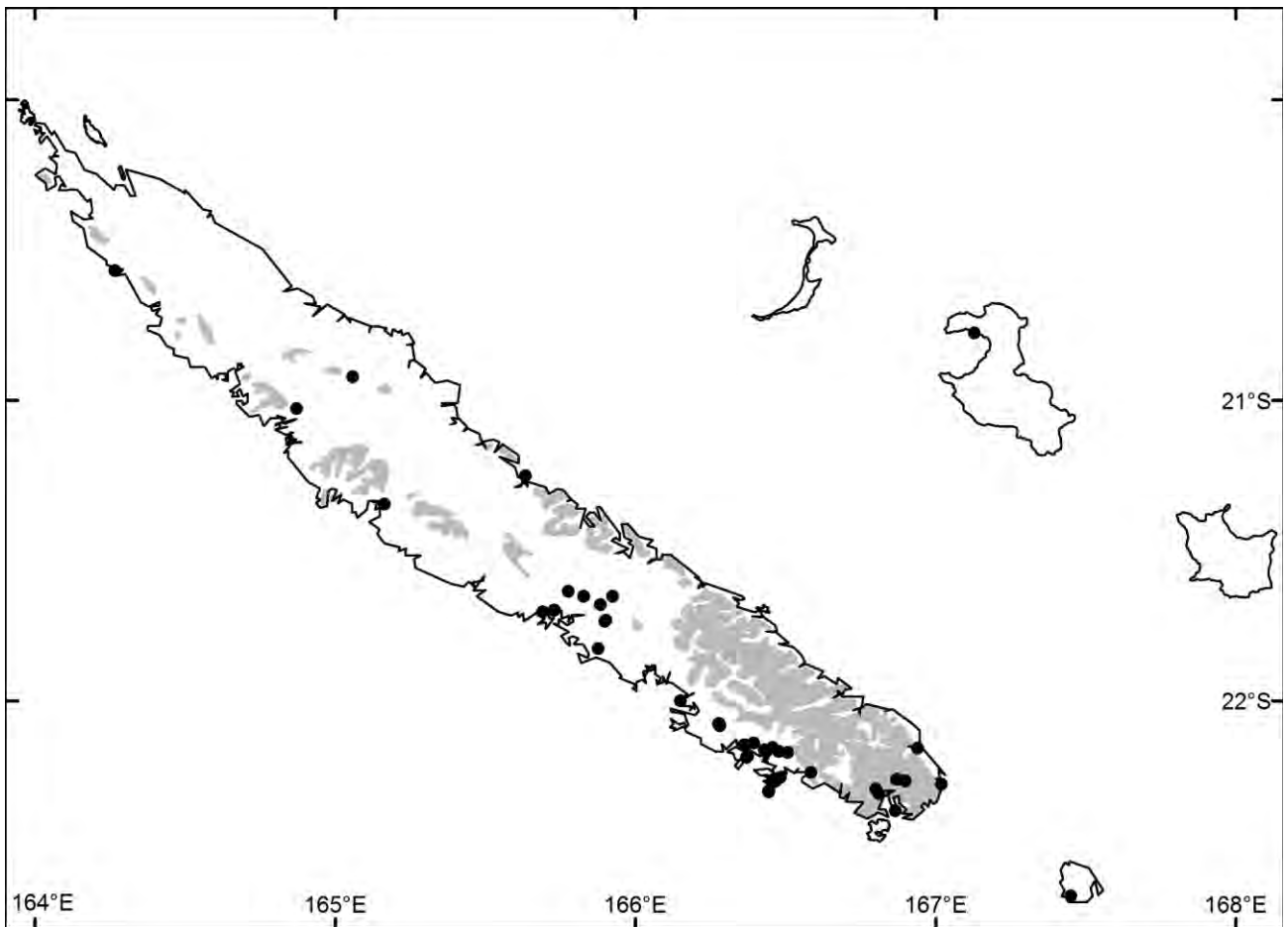


Figure 106. Records of *Tramea transmarina intersecta*.

Habitat. It occurs in sunny standing water habitats, including along the landward border of mangroves, and also calm parts of streams and rivers. It seems to tolerate ultramafic soil.

biology and behaviour. Its behaviour is similar to other New Caledonian *Tramea* Hagen, 1862 species. According to Lieftinck (1976), the larvae cannot be distinguished from *T. transmarina propinqua* Lieftinck, 1942.

Status. Based on its presence at many sites and eurytopic habitat preferences, we consider the species not at risk in New Caledonia (LC).

***Zygomma petiolatum* Rambur, 1842**

(Fig. 107)

Zygomma petiolatum Rambur, 1842: 31; *Zygomma sechellarum* Martin, 1896.

Distribution. This species is recorded from the Seychelles, Mauritius, throughout most of the Oriental Region, the northern part of Australia and few south west Pacific islands (Tsuda 2000). In New Caledonia, it has been recorded as vagrant (Davies 2002) at two locations in the south of Grande Terre, which are however not precisely known. Therefore, we did not map its distribution.

Habitat. we expect that this species in the same habitats as *T. tillarga*, but as it is also semi-crepuscular, fast-flying and less conspicuous it may be a more easily overlooked.

biology and behaviour. The larva was illustrated by Lieftinck (1962). This is a migratory species most active towards dusk.

Status. we considered this species as DD, because little information is available for New Caledonia.



FIGURE 107. *Zygomma petiolatum*, female, Indonesia (E. Nielsen).

Doubtfull records

Tramea limbata (Desjardins, 1832)

Libellula limbata Desjardins, 1832; *Libellula stylata* Rambur, 1842; *Libellula incerta* Rambur, 1842; *Libellula mauriciana* Rambur, 1842; *Libellula similata* Rambur, 1842; *Trapezostigma madagascariensis* Kirby, 1889; *Tramea madagascariensis* Kirby, 1889; *Tramea translucida* Kirby, 1889.

Distribution. This species occurs in subtropical Africa, several islands of the Indian and Pacific oceans, and the Indian subcontinent (Tsuda 2000). There are only a few records for New Caledonia, in the southern half of Grande Terre. It is likely these were misidentifications.

Habitat. This species frequents swamps, ponds and lakes and sometimes calm parts of watercourses, as well as large pools of overgrown creeks and streams located in an open environment.

biology and behaviour. Its larval development is unknown, but Grand (2004b) collected numerous exuviae on Réunion Island. This migrant has pronounced nomadic behaviour and it is not rare to encounter it far from water. Breeding males move alongside or above the water. As for other species in the genus, *T. limbata* has an unusual oviposition technique described above (see *Tramea loewii*).

Status. The occurrence of *T. limbata* in New Caledonia appears doubtful despite some unconfirmed reports. The species may have been confused with *T. liberata* or *T. transmarina intersecta*.

Discussion

Some authors, such as Liefertinck (1975), report *I. torresiana* for New Caledonia. we followed watson (1976) and treated it as synonym of *I. heterosticta*. we also removed *X. cyanomelas*, as mentioned by Liefertinck (1975), from the New Caledonian species list, following Davies (2002). The species was probably accidentally introduced to the island but has now disappeared.

Liefertinck (1975) described a new subspecies named *T. transmarina intersecta* which was treated as a species, *T. intersecta*, by Davies (2002) who did not provide any justification. we do not think that the observed morphological differences of the larva (see Liefertinck 1976) and of the imago justify this change and retain this taxon as a subspecies.

Lippit-willey (1955) reports the capture of a Zygopteran larva, found close to the water, in the litter of a forest and it was inferred that this larva had a terrestrial behavior. Later, winstanley (1983) attributed this larva to *C. uniseriis* and showed it developed in tiny seepages flowing over the ground litter, as does the larva of *S. miranda*. Based on laboratory experiments and reports in the literature, he concluded that, in the tropics, many later-stage dragonfly larvae can leave the water and move onto water saturated forest soil for several hours to a few days, especially when approaching metamorphosis. Under these conditions, winstanley (1983) concluded that *C. uniseriis* and *S. miranda* larvae have some semi-terrestrial to semi-aquatic ecological preferences. During our searches we never found larvae on wet litter along banks of creeks. The few *C. uniseriis* exuviae that we collected were all hanging low in the vegetation immediately bordering water, suggesting that these larvae did not move onto land to find a necessary support for emergence. For *S. miranda*, the situation is slightly different, because males are mainly patrolling over very low seepages on decaying leaves litter, where females lay their eggs. we collected some exuviae of *S. miranda* on tree trunks, which sometimes were three or four metres from such seepages. In search of an adequate support on which to emerge, the larva must occasionally move through the litter. Some larvae in late instars might also live in damp conditions away from the water.

Our knowledge of the distribution of New Caledonian species is still incomplete, although *E. ochraceus*, *C. sarasini*, *C. maculata*, *I. tilyardi*, *I. heterosticta*, *A. exsudans*, *S. fenella*, *S. miranda*, *O. caledonicum* and *D. haematodes* appear to have a large distribution at least on Grande Terre. For many species, however, most records in New Caledonia were in the southern province. This situation is a consequence of sampling bias of collectors who mostly reside in and around Nouméa.

Endemic taxa of Argiolestidae (six species), *Isosticta* (five species) and *Synthemis* (eight species), and also *O. dominatrix* are strictly confined to creeks, streams and rivers. These watercourses often flow under forest cover. The 20 species that depend on rivers for their larval cycle are therefore highly sensitive to habitat loss (through fires

and mining), to the degradation of their biotopes (damage to the banks of streams and rivers) and to water pollution (solid waste, sewage and chemicals, erosion from formerly exploited mines), especially around Nouméa (from Tontouta to Mont-Dore).

Threats from invasive fish must also be considered. Predation pressure on larvae is especially high when poeciliid fish are present, as found in Hawaii (Englund 1999, 2008). In New Caledonia, at least eight alien fish species are recorded from streams and lakes (Pascal *et al.* 2006). The introduction of the litorea frog *Litorea aurea* (Lesson) that occurred within the last 200 years (Pascal *et al.* 2006) is also a factor that may have had an impact on both larvae and adults of some Odonata populations, especially in coastal areas and for sites at low altitude where this introduced species occurs.

Conclusion

New Caledonia hosts 56 species of dragonflies, of which 23 are endemic. The fauna has strong affinities with that of Australasia and to a lesser extent with those of eastern Indonesia and the south west Pacific. During the last decade (between 1999 and 2011), 44 species were recorded. Due to New Caledonia's isolation and high levels of endemism (representing 41% of the New Caledonian species), this insect group is of great interest for preserving regional biodiversity.

From available data on each species (distribution, biology, habitat preferences), we consider that 18 species (34% of odonates) are threatened. Among them, we consider four taxa as critically endangered, these include three endemic species: *C. janicae*, *S. flexicauda* and *S. pamela*. In the case of *S. flexicauda*, the reason of its rarity might be a lack of sampling effort, however this is not the case for the other three species. Factors that threaten Odonata are water pollution, fire and deforestation of the western lowlands (for grazing cattle, agriculture and urbanization). Our insufficient knowledge of the endemic species, which are mostly associated with running water, prevents us from proposing definite conservation measures at present.

Nevertheless we can suggest that conservation efforts be concentrated on endemic species whose ranges are very small or insufficiently known, namely: *C. janiceae*, *I. gracilior*, *I. humilior*, *I. pamela*, *O. dominatrix*, *M. elongata*, *S. pamela*, *S. ariadne*, *S. flexicauda* and *S. serendipita*. It would involve improving our knowledge of distribution as well as conducting population viability analyses. This should help to better assess the IUCN status of each species and indicate the necessary conservation measures. The importance of odonates as bioindicators is worldwide appreciated (e.g. see Boudot & Kalkman 2015). Monitoring programmes have been implemented on a local scale for many countries around the globe based on the so called 'Citizen Science' (for definition see Röller 2016). Such programmes should be developed for Pacific islands such as New Caledonia as recommended by Marinov *et al.* (2013).

Acknowledgements

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Our special gratitude goes to Roberte Grand and Régis Krieg-Jacquier for allowing us access to Daniel Grand's personal photo archive.

Table 2. Status V=visitor, N=native, E=endemic, e=regional endemic (New Caledonia, Vanuatu, Fiji), abundance (1=rare, 2=fairly common, 3=abundant), distribution (1=localised, 2= fairly common, 3=widespread), and proposed conservation status (CR=critical, EN=endangered, VU=vulnerable) in New Caledonia.

Family	Taxa	Status	Occurrence	Distribution	Altitudes (m)	Conservation
Argiolestidae	<i>Caledargiolestes janiceae</i>	E	1	1	100-300	CR
	<i>Caledargiolestes uniseries</i>	E	2	3	0-1300	NT
	<i>Caledopteryx maculata</i>	E	2	1	0-1200	NT
	<i>Caledopteryx sarasini</i>	E	2	2	0-1300	NT
	<i>Eoargiolestes ochraceus</i>	E	2	3	0-1400	LC
	<i>Trineuragrion percostale</i>	E	2	3	0-1400	LC
Coenagrionidae	<i>Agriocnemis exsudans</i>	N	3	3	0-1100	LC
	<i>Austroagrion watsoni</i>	N	1	1	0-500	DD
	<i>Ischnura aurora</i>	N	1	2	0-200	VU
	<i>Ischnura heterosticta</i>	N	3	3	0-800	LC
	<i>Ischnura pamelae</i>	E	1	1	0-400	EN
	<i>Xanthagrion erythroneurum</i>	N	1	1	0-800	VU
Isostictidae	<i>Isosticta gracilior</i>	E	1	1	0-500	EN
	<i>Isosticta humilior</i>	E	1	2	0-500	EN
	<i>Isosticta robustior</i>	E	3	3	0-1100	LC
	<i>Isosticta spinipes</i>	E	2	3	0-1000	VU
	<i>Isosticta tillyardi</i>	E	3	3	0-1100	LC
Lestidae	<i>Indolestes cheesmanae</i>	e	1	2	0-1000	VU
	<i>Lestes concinnus</i>	N	1	2	0-200	VU
Aeshnidae	<i>Aeshna brevistyla caledonica</i>	E	2	1	0-700	NT
	<i>Anaciaeschna jaspidea</i>	N?	1	2	0-100	DD
	<i>Anax gibbosulus</i>	N?	1	2	0-400	DD
	<i>Anax guttatus</i>	N?	1	2	0-100	DD
	<i>Anax papuensis</i>	V	1	1	0-100	DD
	Austrogynacantha heterogena	N?	1	2	0-100	DD
	<i>Gynacantha rosenbergi</i>	N?	1	2	0-500	DD
	<i>Oreaeschna dominatrix</i>	E	1	2	0-400	VU
Corduliidae	<i>Hemicordulia fidelis</i>	E	3	3	0-1100	LC
	<i>Hemicordulia hilaris</i>	N	1	2	0-600	VU
	<i>Metaphya elongata</i>	E	1	1	0-600	EN
Synthemistidae	<i>Synthemis ariadne</i>	E	1	3	0-800	EN
	<i>Synthemis campioni</i>	E	1	3	0-400	EN
	<i>Synthemis fenella</i>	E	3	3	0-1400	LC

...continued on the next page

Table 2. (Continued)

Family	Taxa	Status	Occurrence	Distribution	Altitudes (m)	Conservation
Libellulidae	<i>Synthemis flexicauda</i>	E	1	1	0-1200	CR
	<i>Synthemis miranda</i>	E	3	3	0-1000	LC
	<i>Synthemis montaguei</i>	E	2	3	0-1400	NT
	<i>Synthemis pamelae</i>	E	1	1	0-1000	EN
	<i>Synthemis serendipita</i>	E	1	2	0-900	EN
	<i>Agrionoptera insignis</i>	N	1	2	0-100	DD
	<i>Diplacodes bipunctata</i>	N	2	3	0-700	LC
	<i>Diplacodes haematodes</i>	N	3	3	0-1100	LC
	<i>Diplacodes trivialis</i>	N?	1	1	0-100	DD
	<i>Lathrecista asiatica festa</i>	N	1	1	0-100	DD
	<i>Macrodiplax cora</i>	N	1	3	0-300	DD
	<i>Neurothemis stigmatizans</i>	V	1	1		DD
	<i>Orthetrum caledonicum</i>	N	1	3	0-900	LC
	<i>Orthetrum serapia/sabina</i>	V	1	1	0-100	DD
	<i>Orthetrum villosovittatum</i>	V	1	1		DD
	<i>Rhyothemis graphiptera</i>	N	2	3	0-500	NT
	<i>Rhyothemis phyllis apicalis</i>	E	2	3	0-600	LC
	<i>Pantala flavescens</i>	N	3	3	0-1200	LC
	<i>Tholymis tillarga</i>	V	2	3	0-100	NT
	<i>Tramea transmarina intersecta</i>	E	2	2	0-600	LC
	<i>Tramea liberata</i>	V	1	1	0-200	DD
	<i>Tramea loewi</i>	N	1	1	0-300	VU
<i>Zyxomma petiolatum</i>	V	1	1	0-200	DD	

Table 3. Recorded flight periods of adult Odonata in New Caledonia ('+' indicates imagines have been observed in a given month).

Family	Species	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Argiolestidae	<i>Caledargiolestes janiceae</i>					+	+	+	+				
	<i>Caledargiolestes uniseriis</i>				+	+	+	+	+	+	+	+	+
	<i>Caledopteryx maculata</i>	+	+	+	+	+	+	+	+	+	+	+	+
	<i>Caledopteryx sarasini</i>	+	+	+	+	+	+	+	+	+	+	+	+
	<i>Eoargiolestes ochraceus</i>	+	+	+	+	+	+	+	+	+	+	+	+
	<i>Trineuragrion percostale</i>				+	+	+	+	+	+	+		
Coenagrionidae	<i>Agriocnemis exsudans</i>	+	+	+	+	+	+	+	+	+	+	+	+
	<i>Austroagrion watsoni</i>							+	+	+			
	<i>Ischnura aurora</i>		+	+	+	+	+	+	+	+			
	<i>Ischnura heterosticta</i>	+	+	+	+	+	+	+	+	+			
	<i>Ischnura pamelae</i>					+	+	+	+	+			
	<i>Xanthagrion erythroneurum</i>		+				+	+	+	+			
Isostictidae	<i>Isosticta gracilior</i>				+	+	+	+	+	+			
	<i>Isosticta humilior</i>					+			+	+	+		+
	<i>Isosticta robustior</i>	+	+	+	+	+	+	+	+	+	+	+	+
	<i>Isosticta spinipes</i>			+	+	+	+	+	+	+	+	+	+
	<i>Isosticta tillyardi</i>	+	+	+	+	+	+	+	+	+	+	+	+
Lestidae	<i>Indolestes cheesmanae</i>	+	+	+	+	+	+	+	+	+	+	+	+
	<i>Lestes concinnus</i>			+	+	+	+	+	+	+			
Aeshnidae	<i>Aeshna brevistyla caledonica</i>			+			+	+	+	+			
	<i>Anaciaeschna jaspidea</i>					+	+	+	+	+	+	+	
	<i>Anax gibbosulus</i>				+	+	+	+	+	+			
	<i>Anax guttatus</i>					+		+	+	+			
	<i>Anax papuensis</i>					+			+				
	<i>Austrogynacantha heterogena</i>								+				
	<i>Gynacantha rosenbergi</i>				+			+		+			+
	<i>Oreaeschna dominatrix</i>				+	+	+	+	+	+	+		
Corduliidae	<i>Hemicordulia fidelis</i>	+	+	+	+	+	+	+	+	+	+	+	+
	<i>Hemicordulia hilaris</i>			+	+		+	+	+	+	+		
	<i>Metaphya elongata</i>							+	+	+			

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Table 3. (Continued)

Family	Species	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Synthemistidae	<i>Synthemis ariadne</i>				+	+	+	+	+				
	<i>Synthemis campioni</i>						+	+	+	+	+	+	
	<i>Synthemis fenella</i>	+	+	+	+	+	+	+	+	+	+	+	
	<i>Synthemis flexicauda</i>							+	+	+	+	+	
	<i>Synthemis miranda</i>				+	+	+	+	+	+	+		
	<i>Synthemis montaguei</i>							+	+	+			
	<i>Synthemis pamelae</i>								+	+	+	+	
	<i>Synthemis serendipita</i>					+	+	+	+	+			
Libellulidae	<i>Agrionoptera insignis</i>					+	+						
	<i>Diplacodes bipunctata</i>	+	+		+			+	+	+		+	
	<i>Diplacodes haematodes</i>	+	+	+	+	+	+	+	+	+	+	+	+
	<i>Diplacodes trivialis</i>												
	<i>Lathrecista asiatica festa</i>				+								
	<i>Macrodiplax cora</i>		+			+		+	+	+			
	<i>Neurothemis stigmatizans</i>							+					
	<i>Orthetrum caledonicum</i>	+	+	+	+	+	+	+	+	+	+	+	+
	<i>Orthetrum serapia/sabina</i>								+				
	<i>Orthetrum villosovittatum</i>												
	<i>Rhyothemis graphiptera</i>								+	+	+	+	+
	<i>Rhyothemis phyllis apicalis</i>				+	+	+	+	+	+	+	+	
	<i>Pantala flavescens</i>				+	+	+	+	+	+	+	+	+
	<i>Tholymis tillarga</i>					+		+	+	+	+		
	<i>Tramea transmarina intersecta</i>		+		+	+	+	+	+	+	+	+	+
	<i>Tramea liberata</i>								+		+		
	<i>Tramea loewii</i>								+	+	+		
<i>Zyxomma petiolatum</i>										+			
		13	17	20	29	35	34	46	48	46	27	22	16

Table 4. Habitats of Odonata in New Caledonia (+ occurrence of imagines, R= reproduction)

Family	Species	Forest	Open areas	Proportion of locations on ultramafic soils	Spring	Mountain current	Lowland river	Swamp	Lake
Argiolestidae	<i>Caledargiolestes janiceae</i>	+		(-)		R			
	<i>Caledargiolestes uniseriis</i>	+		8%	R	R			
	<i>Caledopteryx maculata</i>	+		54%	R	R			
	<i>Caledopteryx sarasini</i>	+	+	2%	R	R			
	<i>Eoargiolestes ochraceus</i>	+	+	11%		R	R		
	<i>Trineuragrion percostale</i>	+		4%		R	+		
Coenagrionidae	<i>Agriocnemis exsudans</i>	+	+	6%		+	R	R	R
	<i>Austroagrion watsoni</i>	+	+	64%					R
	<i>Ischnura aurora</i>		+	-			R	R	R
	<i>Ischnura heterosticta</i>	+	+	11%		+	R	R	R
	<i>Ischnura pamela</i>		+	81%				R	R
	<i>Xanthagrion erythronurum</i>	+	+	-			+	+	R
Isostictidae	<i>Isosticta gracilior</i>	+	+	82%			R		
	<i>Isosticta humilior</i>	+		-		R	R		
	<i>Isosticta robustior</i>	+	+	26%	+	R			
	<i>Isosticta spinipes</i>	+		27%		R			
	<i>Isosticta tillyardi</i>	+		16%		R	R		
Lestidae	<i>Indolestes cheesmanae</i>	+		7%			+	R	R
	<i>Lestes concinnus</i>	+	+	-			+	R	R
Aeshnidae	<i>Aeshna brevistyla caledonica</i>	+	+	59%			+	R	R
	<i>Anaciaeschna jaspidea</i>	+		-			+	R	R
	<i>Anax gibbosulus</i>	+		-			+	R	R
	<i>Anax guttatus</i>		+	-			+	+	R
	<i>Austrogynacantha heterogena</i>	+	+	-			+	R	R
	<i>Gynacantha rosenbergi</i>	+	+	-			+	R	R
	<i>Oreaeschna dominatrix</i>	+		60%		+	R		
Corduliidae	<i>Hemicordulia fidelis</i>	+	+	30%		+	R	+	R
	<i>Hemicordulia hilaris</i>	+	+	59%			+	R	R
	<i>Metaphya elongata</i>	+	+	61%			?	?	?
Synthemistidae	<i>Synthemis ariadne</i>	+		-		R			
	<i>Synthemis campioni</i>	+		-		R			

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Table 4. (Continued)

Family	Species	Forest	Open areas	Proportion of locations on ultramafic soils	Spring	Mountain current	Lowland river	Swamp	Lake
	<i>Synthemis fenella</i>	+	+	19%		R	R		
	<i>Synthemis flexicauda</i>	+	+	43%		R			
	<i>Synthemis miranda</i>	+	+	12%	R	R			
	<i>Synthemis montaguei</i>	+		17%		+	R		
	<i>Synthemis pamela</i>	+	+	33%		+	R		
	<i>Synthemis serendipita</i>	+		11%		R			
Libellulidae	<i>Agrionoptera insignis</i>	+	+	-			+	R	R
	<i>Diplacodes bipunctata</i>	+	+	13%			+	R	R
	<i>Diplacodes haematodes</i>	+	+	18%			+	R	R
	<i>Diplacodes trivialis</i>								
	<i>Lathrecista asiatica festa</i>	+	+				+	R	R
	<i>Macrodiplax cora</i>		+	22%			+	R	R
	<i>Neurothemis stigmatizans</i>	+					+	R	R
	<i>Orthetrum caledonicum</i>	+	+	22%			R	R	R
	<i>Orthetrum serapia/sabina</i>	+	+	-			+	R	R
	<i>Orthetrum villosovittatum</i>	+	+				+	R	R
	<i>Rhyothemis graphiptera</i>	+	+	5%			+	R	R
	<i>Rhyothemis phyllis apicalis</i>	+	+	-			+	R	R
	<i>Pantala flavescens</i>	+	+	27%			+	R	R
	<i>Tholymis tillarga</i>	+	+	-			+	R	R
	<i>Tamea transmarina intersecta</i>	+	+	20%			R	R	R
	<i>Tamea liberata</i>	+	+	33%			?	?	?
	<i>Tamea loewii</i>	+	+	75%			+	R	R
	<i>Zyxomma petiolatum</i>	+	+	50%			+	R	R

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