Chapter 5

Damselflies and Dragonflies (Insecta: Odonata) of the Mt. Panié and Roches de la Ouaième region, New Caledonia

Inventaire odonatologique du massif du Panié et des Roches de la Ouaième, Nouvelle-Calédonie

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SUMMARY

We surveyed odonates at 46 sites in north-eastern New Caledonia, including 38 primary sites in three catchments on and around Mt. Panié. A total of 23 species were recorded during this survey, which comprises 41% of the 56 species known for the country. The lowest number of species was documented within the La Guen river catchment, where less species were found than in the Dané Yém river catchment despite only limited sampling (half a day) at this latter site. Localities within the La Guen catchment also appeared to suffer from higher disturbance compared to those in the Wewec river catchment where species richness was high. They had lower water pH, higher amounts of filamentous algae and an apparently low abundance of primary consumers (macroinvertebrates). Anthropogenic impacts, including bushfires and introduced mammals, may these differences. Our results suggest that odonates are useful bioindicators within the Mt. Panié area. This survey has provided baseline data on species occurrence and abundance at a range of sites, and identified several questions regarding disturbance to aquatic ecosystems that require further investigation.

RESUME

En Octobre 2010, les Odonates de 46 sites de la région du Mont Panié ont été évalués, dont 38 sites principaux au sein de trois bassins versants autour du Mont Panié. 23 taxons ont été inventoriés soit 41% des 56 espèces connues en Nouvelle-Calédonie. Le bassin versant de La Guen, moins riche que les autres sites, semble être perturbé : pH de l'eau inférieur, importantes quantités d'algues filamenteuses et faible abondance des consommateurs primaires (macroinvertébrés). Les impacts anthropiques, y compris les feux de brousse et les mammifères exotiques envahissants, peuvent contribuer à ces observations. Nos résultats suggèrent que les Odonates peuvent être d'utiles bioindicateurs des cours d'eau de la région du Mont Panié et cette évaluation a fourni des données de base sur la présence et l'abondance des espèces sur une série de sites. Les questions concernant les perturbations des écosystèmes aquatiques nécessiteraient un travail de recherche.

INTRODUCTION

Spellerberg (2005) comments on the importance of national and international State of the Environment (SoE) reporting for answering crucial questions about the trends, pattern and changes in our environment. He lists 41 countries which already have produced these valuable assessments on their environments and emphasises the importance of "scientifically defendable information on the environment at different stages in time so that we can make temporal comparisons" (Spellerberg 2005: 80). Plant and animal species used as bioindicators play a vital role in this process. The United States' Environmental Protection Agency developed six general criteria for an environmental indicator to be considered as "useful; objective; transparent; and based on data that are high-quality, compatible, and representative across space and time" (U.S. EPA 2008). Following these criteria, and applying them to the characteristics of biological organisms that may be used as bioindicators requires consideration of a) their biological and ecological potential for answering specific questions, b) confidence that data about the group come from accurate statistical procedures and scientifically robust methods, and c) knowledge that these organisms can be used at different temporal and spatial scales for providing information about changes in ecological systems.

Odonata (hereafter *odonates* or *dragonflies*) qualify as reliable indicators based upon all the criteria above. These insects have been intensively studied worldwide because they have an important role as indicators of the ecological quality

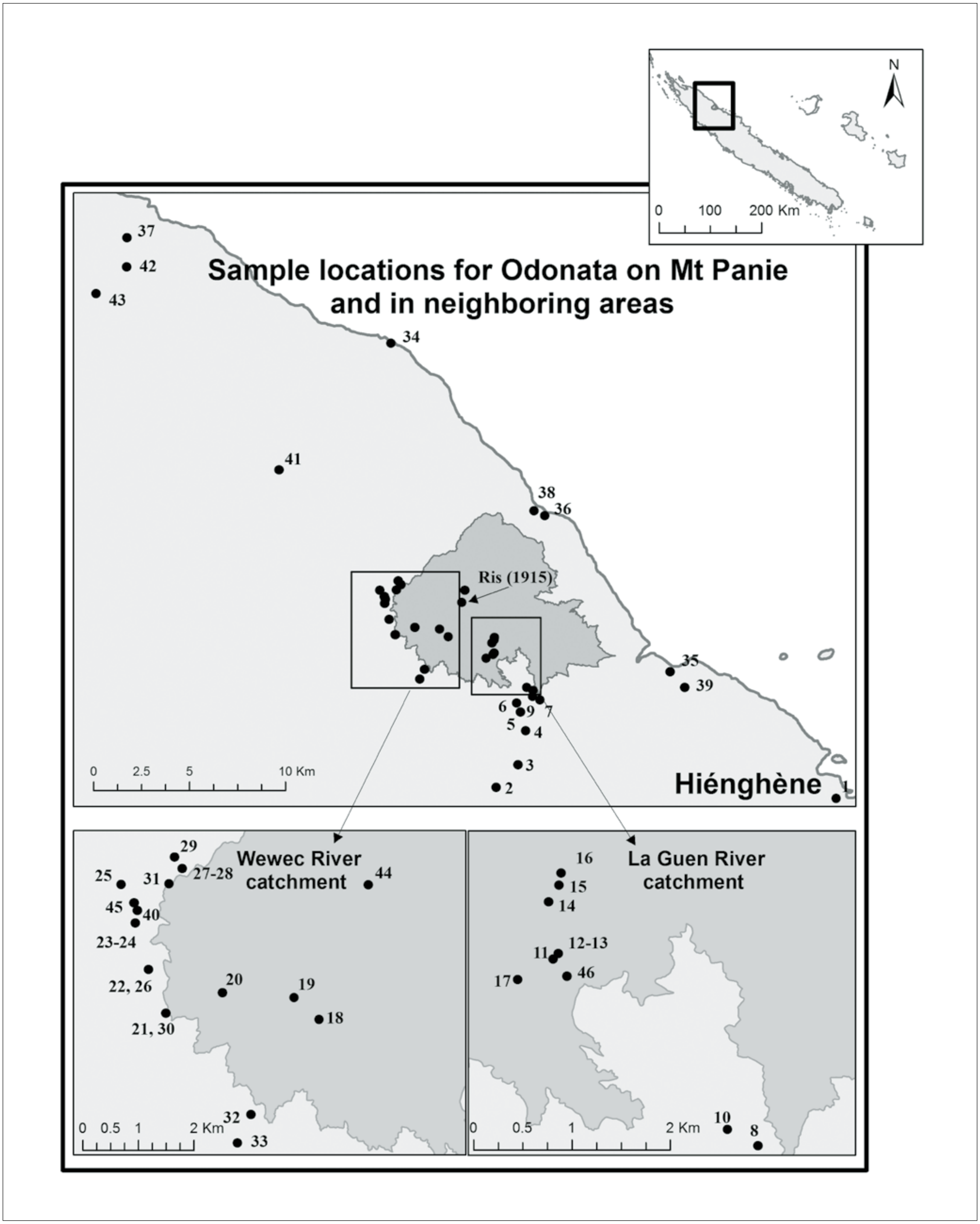

Figure 1: Odonata sampling localities during the New Caledonia 2010 RAP survey, including historical sampling localities. Shaded area represents the Mt. Panié Wilderness Reserve.

of land-water ecotones, habitat heterogeneity (Chovanec 2000), water pH, salinity and pollution (Corbet 1993), and have been used for developing various biotic indices (Simaika and Samways 2009). Several morphological features and behaviour patterns make these insects important in environmental assessment projects and fulfil the set of criteria introduced by U.S. EPA (2008). Dragonflies are large and conspicuous (Sahlén and Ekestubbe 2001) and therefore much easier to detect and to identify in flight; imagos (males particularly) usually stay close to water bodies where the development of the larvae takes place (Corbet 1999); species inhabit a wide spectrum of aquatic and terrestrial habitats as larvae and adults (Briers and Biggs 2003); and populations respond rapidly when terrestrial or aquatic environments are disturbed by human-induced or natural environmental changes (Catling 2005), such as temperature shifts (Oertli 2010). In summary many dragonflies need water of specific quality, specific sediment composition and aquatic/terrestrial vegetation of unique structure in order to complete their life cycles. Because different species require different combinations of natural features (both aquatic and aerial), regions with higher habitat heterogeneity tend to have correspondingly higher species diversity. Some species are highly specialised (*stenotopic*) and populations will therefore respond rapidly and drastically to modification of any environmental parameters. These species may be powerful bioindicators of ecosystem health.

However, the indicator value of species must be assessed separately for each country. This is especially true for regions exhibiting endemism at higher taxonomic levels – genus and above. Unfortunately such evaluations are largely lacking for the Pacific island nations even for those with very thorough faunistic data. New Caledonia exemplifies this situation. No in-depth ecological evaluation of the odonate fauna of the country has been yet undertaken. Previous studies have mainly focused on taxonomy and distribution, although Winstanley (1983, 1984a) provided useful ecological information about the larvae of several species. As a result the bioindicator value of New Caledonian Odonata species is still underestimated, although the two biotic indices of water quality developed for the country – the Biotic Index of New Caledonia (IBNC) and Bio-Sedimentary Index (IBS) – use Odonats at the family taxonomic level (Mary 1999, Mary com pers). Considering the importance of this issue for future environmental assessments within the region, the present study was specifically designed to improve understanding of New Caledonian dragonfly ecology, biology and taxonomy.

METHODS AND DESCRIPTION OF STUDY SITES

A total of 38 primary and 8 additional localities were sampled within the study area and some adjacent sites along the north-eastern coast of New Caledonia between 09–21 October and 01–15 November 2010. Initials in brackets relate to the names of the authors who provided the data. Identification was done either by direct observation in natural conditions with binoculars (Opticron Discovery 10×42) or by capture with a collecting permit issued by Province nord. Adults (*imago*) were captured with an aerial net (45 cm ring diameter and 60 cm handle length) and 112 individuals were killed in 90% ethanol or in acetone. Later, they were dried at air temperature, transferred to paper envelopes and kept in a water-proof box containing silica gel. Larvae were collected with a dip net from vegetated stream banks or from under stones on the stream bed. Sites were also checked for freshly emerged individuals (*tenerals*) and larval skins (*exuviae*). Totals of two larvae, 26 tenerals (some with their exuviae) and 37 exuviae were collected.

Environmental characteristics important for description of the individual species' habitat types were measured at primary sampling locations. These are given below with the type of equipment (in brackets) used for each measurement:

1. vegetation cover (convex spherical densitometer Model A)
2. light intensity (digital lux tester YF-1065)
3. water pH (Whatman paper strips)
4. water temperature (Brannan hand thermometer)
5. river/stream width and depth (Celco ruler)
6. sediment depth (Celco ruler)
7. water velocity (ruler method according to Harding et al. (2009))

These were required for preparing both qualitative and quantitative assessments of the sites according to the protocol described in Harding et al. (2009). For this publication, we present a qualitative approach to data analysis; a more quantitative assessment of habitat relationships of each species will be published separately. Additional measures of algal and invertebrate abundance were estimated visually.

Coded species abundance was estimated per locality following Stark et al. (2001). Dragonfly species fell into four classes: 1) **R** (rare) – 1 to 4 individuals; 2) **C** (common) – 5 to 19 individuals; 3) **A** (abundant) – 20 to 99 individuals; and 4) **VA** (very abundant) – 100 to 499 individuals.

Species of conservation importance have been assessed in terms of their rarity within the region, their global distribution, general impressions of population size, and possible threats observed during the Mt. Panié RAP survey.

A list of localities in the Mt. Panié area is presented in Fig. 1, including all places sampled during the Mt. Panié RAP survey with additional information collected by one of the authors (JT) in earlier years. Unless specified, all dates refer to the actual period of the Mt. Panié RAP (October - November 2010). Locality names (Appendix 1) were specified after consultations with the local guides.

RESULTS AND DISCUSSION

We recorded 23 species (Appendix 2) and collected 177 individuals. The primary localities sampled around Mt. Panié occur within three catchments: Dané Yém river, La Guen river and Wewec river (Fig. 1; Appendix 1). The lowest number of species was documented within the La Guen river catchment (10 species), where less species were found than in the Dané Yém river catchment (11 species) despite the limited sampling effort (half a day) at this latter site (Appendix 2). The Wewec river catchment supported the richest odonate community, with 19 species.

Species abundance varied strongly among catchment areas (Fig. 2) and sampling sites (Appendix 2). Peaks in the abundance of individual species, especially in the Dané Yém and La Guen river catchments, probably reflect the distribution of habitat types and the degree of habitat disturbance. Total abundance in the Dané Yém river catchment may have been reduced by lower sampling effort, although the abundance peaks of both *Diplacodes haematodes* and *Agriocnemis exsudans* probably reflect the prevalence of sunny banks along the main river, springs with corresponding pools, and backwaters (stagnant water bodies connected to the main stream) lined with rocks and marginal vegetation. All but one biotope visited in the Dané Yém river catchment could be characterised in this way. The only exception is locality 5 – a stream flowing through forest area with densely vegetated banks and a high percentage of tree canopy cover over the water surface. Boulders inside the stream contributed to high habitat heterogeneity, which may explain the comparatively high number of species despite the short visit (Appendix 1).

The dominance of shady forest streams and rivers up to 10 m wide could also explain the peaks in abundance of certain species within the La Guen river catchment area. This is especially true for *I. spinipes* which has apparent affinity towards such habitats. The peaks observed for *C. sarasini* could be linked to the preferences of adults towards cascades and small waterfalls, which are quite typical among the biotopes visited within this area. *O. caledonicum* is another species which shows high relative abundance within this catchment. Most adults of this species were encountered on the slopes above the main water bodies, which are likely to represent individuals wandering from their typical reproductive sites. *A. ochraceus* is the last species with very high abundance in one particular locality. No obvious explanation is available for this phenomenon so far. It may reflect species-specific responses to habitat disturbance or to altitudinal effects but these possibilities require further investigation. Some further comments are provided below.

Out of species occurring at multiple sites, only one species showed a peak in abundance within the Wewec catchment, while several species showed a peak in abundance at La Guen (Dane Yem is excluded from this comparison since precise environmental variables were not measured). These particular species may tolerate and/or benefit from higher disturbance at La Guen. Sites within the La Guen river catchment (especially localities 11–12) had lower water pH, higher amounts of filamentous algae and low abundance of primary consumers (macroinvertebrates). Only one locality (number 23) from Wewec river had similar water pH and correspondingly high algae, and this site is adjacent to the gite of Thao. It has experienced severe anthropogenic impacts and receives high input of nutrients such as nitrogen and phosphorus. Human activities on their own, however, do not appear to explain the situation observed at Sites 11–12 (Kompwara river), where human impact appeared to be minimal. The main anthropogenic impacts within the area used to be, and occasionally still are, bush fires. They may increase the nutrient load in waterways and could be a great danger in ecological systems like lakes and marshes where runoff is captured due to the inflow from surrounding slopes, leading to an overall increase in water mineralization. Smith et al. (2011) provide an overview of experiments associated with

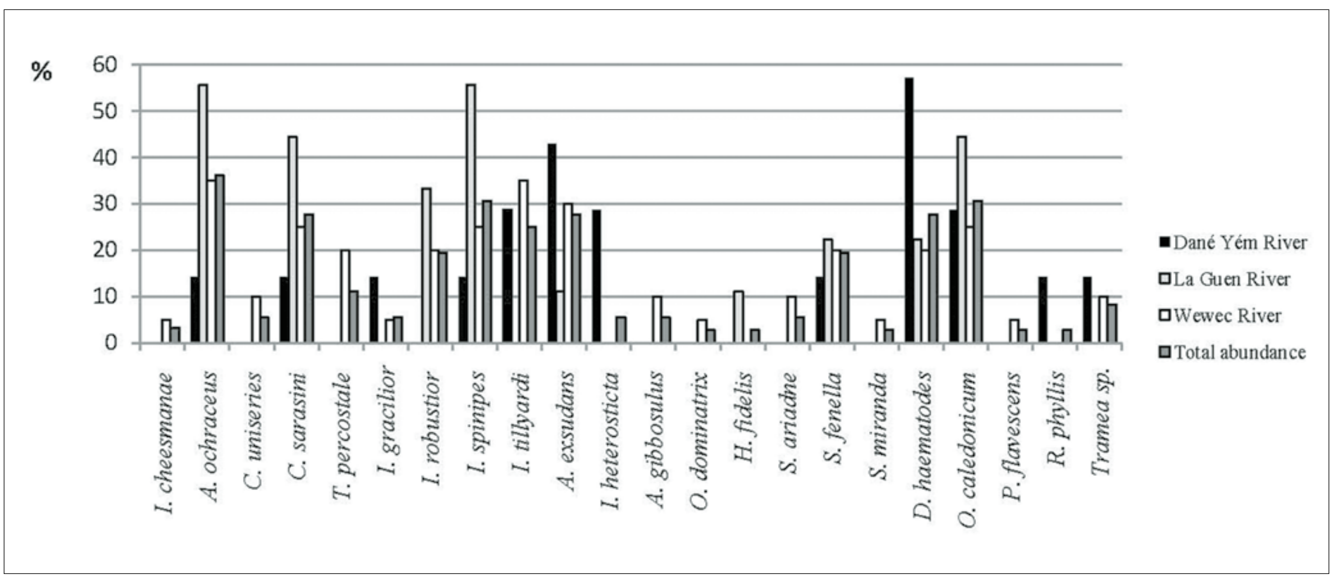

Figure 2: Relative abundance of Odonata species per catchment area and for the total study area. The figure is prepared for the primary sampling locations and does not include *Isosticta humilior* discovered at the additional sampling localities.

bush fires, which have found increased levels of nitrogen and phosphorus associated with post-fire atmospheric and runoff inputs such as ash, as well as soil erosion. However, the persistent algae observed just below Refuge Blaffart is unlikely to be influenced by bush fires, since the upper part of the catchments are fully forested. Also, the current in the river was as fast as 140 cm/s which should be enough to flush the captured nutrients and release the system of the overload. Dense tree canopy is usually associated with lower primary production of the water compared to stretches exposed to sunlight, and should suppress algal growth (Bernot et al. 2010). The filaments at locality 11, however, were observed under mean vegetation cover of 95% (ranging between 30%-100%) and covered as much as 80% of the stone surfaces, suggesting other anthropogenic causes of algae proliferation.

Bush fires could have other impacts – for example by increasing water alkalinity, which could be a big shock for aquatic communities (Earl and Blinn 2003). Even though the stream current washes away the ash, the sudden change in water chemistry might be fatal for invertebrates. Low abundance of macroinvertebrates may indicate a disturbed aquatic system. Mayfly or stonefly larvae are usually abundant in a healthy aquatic system and are often sampled together with odonate larvae. However, they were completely lacking in the samples at sites 11 and 12. In fact the only invertebrates found at those sites were oligochaetes, which are usually given very low sensitivity scores (Stark and Maxted 2007). A lack of primary consumers in the system, where they act as grazers on the growing algae, reduces the self-purification abilities of the rivers and could explain the low species diversity of predatory organisms like odonates. Only one Odonata species (*I. robustior*) was confirmed to be breeding at these sites, based on a single specimen with its exuvia, although six species (*A. ochraceus*, *C. sarasini*, *H. fidelis*, *S. fenella*, *O. caledonicum* and *D. haematodes*) may also find suitable habitats to breed there. *A. ochraceus* was the dominant species at site 16 too, where it was observed in relatively high numbers compared to the other sites within the catchment. Its prevailing role in the system at this altitude should be investigated further because a sole organism dominating a normally diverse community may be an alarming indicator of disturbance. Death and Winterbourn (1995) commented on species diversity that declined following the decrease of stream stability (measured as discharge variability, physical and chemical characteristics) in Cass-Craigieburn region, New Zealand.

Altitudinal effects also influence species composition and community structure. Fewer odonate species within La Guen catchment could be a result of the higher elevations (ranging between 522–760 m a.s.l.; locality 8 situated at 83 m a.s.l. is excluded as it was sampled during bad weather conditions) of localities there than in the Wewec catchment which were just 55–472 m a.s.l. Also, the field surveys took place early in the flying season. Although the phenology of New Caledonian dragonflies is poorly understood, Davies (2002) found only two species flying from October onwards. The beginning of the flying season at higher altitudes is usually postponed (Corbet 1962) so sampling regimes that include periods of peak flying season might provide quite different results from those reported here.

The observed differences in species abundances between the two catchments are unlikely to be attributed to bad weather. Poor atmospheric conditions (dense cloudiness, rain and lower temperatures) could definitely have a negative effect on dragonfly flight activity, however they do not appear to explain the low abundance of macroinvertebrate taxa within La Guen catchment. Aquatic larvae have no other place to hide during rain and would be present within the sampling localities. Moreover the bad weather conditions were experienced only once during the sampling period. Unfortunately that was the day when the La Guen main river stream was investigated, which probably led to the low species richness observed at this site. No habitat comparable to this site was encountered within La Guen catchment, although locality 26 within Wewec catchment resembled the general appearance of La Guen. Locality 26 contributed one new species for the RAP and five more were collected as well. Six species (all of them collected as breeding) is a number that ranks this site amongst the localities with highest species diversity. High species diversity is typical of other localities within Wewec catchment (localities 20, 27, 32 and to some extent 23, 29). Small densely vegetated springs situated at the bottom of deep gullies were another peculiarity of sites visited within Wewec catchment. Some of them (localities 28 and 29) were investigated for a very short time, but the results were evident of their high conservation importance. Five of the species listed below as "Interesting" (*Caledargiolestes uniseries*, *Trineuragrion percostale*, *Caledopteryx sarasini*, *Isosticta spinipes* and *Argiolestes ochraceus*) were discovered in both of them. Although not included in any particular conservation list *Indolestes cheesmanae* deserves special attention and was represented by only two males found in Wewec catchment. Its typical habitat is comprised of small shady slow flowing streams with plenty of aquatic vegetation.

INTERESTING SPECIES OR GENERA

A total of 23 taxa were recorded during this survey, which is 41% of the 56 species known for the country (Appendix 2). Accounts for all species are given in Appendix 3 and short accounts for individual species of conservation importance are given below. They emphasize particularly those species with restricted ecological niches and area of occupancy, which are often referred to as *rare* species, those included on the IUCN Red List (2010) and those species that constitute potentially good bio-indicators. Endemism alone, at the scale of New Caledonia, is not considered to be of critical importance because several endemic species occur in very large numbers across much of the country. Davies (2002) is used here as the primary reference for previous records for the country. Nine species accounts are presented here in decreasing importance according to conservation priority rather than following any particular taxonomic order.

Synthemis ariadne. Only three previous records are known for the country (Lieftinck 1975, Winstanley 1984a, b), with four observations during this survey near sites 20, 39 and 40. The presence of a newly emerged male indicates that the species possibly breeds in locality 20 although one female was observed at site 18 about 1,700 m away from water, providing evidence of the long distance that individuals of this species can travel. Its conservation status within the Mt. Panié area remains unclear.

Isosticta robustior. Regionally common in shallow stony rivers, this species was found (including breeding individuals) at nine sites, but represented by single individuals only. This low abundance probably reflects the fact that our observations were made early in the flying season. Its conservation status within the Mt. Panié area remains unclear.

Caledargiolestes uniseries. Davies (2002) lists this species as common and widespread in New Caledonia, but *C. uniseries* was found in only four small streams during the present research. It may be that our survey was conducted outside the typical flying season for this species, which was given as November to April by Davies (2002).

Trineuragrion percostale. This species is listed as Least Concern by the IUCN. It was found mainly within the Wewec catchment area and in one locality (locality 35) near the coast.

Caledopteryx sarasini. This species is listed as Least Concern by the IUCN. It is one of the most abundant species along streams around Mt. Panié where it was mainly encountered near waterfalls (see Appendix 3). Consequently, this species may serve as an indicator of fast flowing streams with boulders and frequent waterfalls.

Hemicordulia fidelis. This species is listed as Least Concern by the IUCN. It was confirmed at three localities (localities 13, 39, 40) within the study area, but possibly is more common, as many *Hemicordulia* spp. individuals were spotted flying at other places.

Isosticta spinipes. This species is listed as Least Concern by the IUCN. It is one of the most abundant species around Mt. Panié. Since it showed a preference for deep, shady parts of streams, *I. spinipes* is a potential indicator of flowing waters with banks overgrown by tall trees.

Synthemis miranda. This species is listed as Least Concern by the IUCN. It was found at four localities within the study area, but probably will be discovered in other sites, since Davies (2002) reports that it is a common species in all wooded areas of New Caledonia.

Argiolestes ochraceus. One of the most common species within the investigated area, *A. ochraceus* is also regularly reported from other parts of the country. The reason it is included among the priority species is its probable value as an indicator species. It is unmistakable in flight and normally occurs at similar or lower abundance than other species from the same site. *A. ochraceus* was the dominant species at site 16, with numerous individuals flying. This locality had clear water, no fish, was free of algae and looked very good for odonates, yet no other species were found. We cannot yet explain the dominance of *A. ochraceus* at this site relative to other sites. Whether this dominance is related to altitudinal preferences or has anything to do with significant disturbance of the area must be established with further research.

CONSERVATION RECOMMENDATIONS FOR EACH SITE

Our qualitative observations on water quality and odonate faunas of the two main catchment areas investigated raise some important issues. The inferred disturbance of the La Guen river system should be a priority for future investigations. The main focus should be on determining the reasons for algae proliferation in this catchment. Samples should be taken and analyzed in order to establish: a) what algae species is blooming in the sites; b) any information about the biology and ecology of this algae species; c) its global distribution; d) potential threats caused by this species (if any) reported in other regions; e) management practices already undertaken.

If human activities (especially bushfires) are not responsible, another possible explanation for algae proliferation could be underground discharge to aquatic systems. The geology of the region should also therefore be considered. Potential pollutants, if any, may be in the form of heavy metals introduced to the system, leaf litter decomposition and leakage of low pH waters, or nutrient enrichment from the faeces of invasive mammals. An experimental pest control programme focusing on deer and pigs might reveal the potential threats to the water quality and associated dragonfly communities. Lack of hunting activities, for example, could be an explanation if the pest control program establishes that there are increased numbers of invasive mammals within the La Guen catchment area.

Invasive mammals may also impact waterways by eroding steep slopes, thereby increasing levels of fine sediments, like silt and sand, in the rivers.

The conservation measures proposed above address the broad environmental issues observed within the study area and should be considered for both main catchment areas. Wewec catchment may look better in terms of species number, relative abundance and species autochthony, but this situation could easily change if our recommendations are not addressed appropriately. Wewec also harbours an interesting type of habitat not encountered in La Guen – little streams (trickles at some places) which flow on the bottom of shady gullies. The stream slopes rise almost perpendicularly to the ground and the bottom is covered by bed-rock and boulders. A recommendation here would be to check with local people for any other streams that match this description in both catchments and to map them for future planning of conservation activities focusing on Odonata. These activities are outlined below, and they reflect the fact that the region's odonate fauna remains poorly documented. Basic species inventory remains a priority for future research on dragonflies, and should be conducted in all seasons for at least two consecutive years. These results are required to build upon the preliminary results reported here, and to establish each species' flight periods, daily activities, preferences for specific habitats and altitudinal distribution. Broader ecological studies that attempt to link individual species' activity patterns and habitat occupancy with local climatic attributes, and with physical and biological (especially invasive species abundance and impact) attributes of local aquatic and nearby terrestrial environments, will help in establishing specific Odonata Habitat Indices similar to those generated in other countries (Chovanec and Waringer 2001, Simaika and Samways 2009). Such indices are easy to use and do not require highly specialised skills for utilisation in the field. Moreover they can be adapted to the local situation before being incorporated into site management practices, making them a very powerful tool. With a little training they could be introduced to and become part of the community engagement practices. Two-year monitoring would contribute to a more complete understanding of the Odonata fauna of the region. These species could be highlighted in simple to use colour guides and given to local communities that would like to be engaged in the process of data collection.

The advantage of using odonates is related to their morphological structure (which makes them highly conspicuous), ecology and biology, which is commented upon in the introduction. However, preliminary work is required before utilising these, and any other, particularly sensitive insects (bioindicators) for environmental appraisals (Mary 1999). The two biotic indices for New Caledonia operate on high taxonomic level (family) for odonates. The Biotic Index of New Caledonia (IBNC) shows the disturbance of the water quality by organic pollution (Mary 1999) and the Bio-Sedimentary Index (IBS) reflects the state of the rivers in terms of sediment transport and pollution from the mining industry (F. Tron pers. comm.). Family level works well for Lestidae where only one species (*Indolestes cheesmanae*) is known as a possible inhabitant of lotic habitats in New Caledonia. However, even for this species the larva has been described by supposition in Lieftinck (1960) and the actual association to the adult needs verification. Family level may also be used for monotypic groups such as Isostictidae with only one genus (*Isosticta*) established for the country. The present study, however, provides evidences for individual species preferences to a particular type of habitat (explained in greater details in Appendix 3). Assigning one value for all five *Isosticta* species may not be appropriate for assessments at a regional level. Similar pitfalls may arise for representatives of Megapodagrionidae. There are six species from four genera known from New Caledonia. Some of the preliminary quantitative results of the current study show that species distribution, and probably also morphology, within the country are influenced by the type of stream/river, altitude and geographical location. This is why the application of IBNC for Mt. Panié must be done after further work on the individual species' indicator value.

There is good existing information to assist such a study. Larvae of new caledonian odonates have not been studied since Lieftinck (1976) which presents the only identification keys for some of the pre-imaginal stages of these insects. However, the opportunistic samples that followed this study (including the present research) shed some light on particular morphological structures that enable species identification during these early stages. The larva of *Trineuragrion percostale* was discovered during the current study and its description was published in Marinov (2012). This would make a considerable contribution to the identification of all Megapodagrionidae larvae. Two more megapodagrionids belonging to separate genera still lack larval description, but could probably be identified based upon larvae of their closest relatives from the same genus that have already been described. Lieftinck (1976) provides a key for distinguishing between three *Isosticta* species (*robustior*, *spinipes* and *tillyardi*). Larva of the fourth species (probably *gracilior*) was discovered from La Guen river and needs to be associated to the actual species. This would nearly complete the morphological description of the entire family for New Caledonia. The revision of genus *Synthemis* is undergoing, with all but one species (*pamelae*) already with known larvae (G. Fleck pers. comm.). A revision on the collected material during the preparation of the IBNC is planned. It will definitely increase the understanding of the new caledonian odonates larval fauna and probably will result in the first complete larval identification key for the country. Such tools are especially important for countries like New Caledonia and other Pacific island nations where the degree of faunal endemism is very high.

Endemic species have frequently been the focus of conservation assessments and other studies, but their importance should not be assessed to the exclusion of other taxa inhabiting the studied area. A conservation list will be most useful when each species is given a relative conservation value in terms of its local and global distribution, ecological plasticity and vulnerability. Such a list may indicate that endemism is not the only predictor of vulnerability, and that non-endemic species face greater threats due to climatic shift, habitat disturbance, predation, or impacts of invasive species. Monitoring of dragonfly populations will reveal trends in their populations and will help to identify species that should be conservation priorities.

Monitoring is also important for understanding the impact of invasive dragonfly taxa, especially those with long distance dispersal capacity. Species from the genera *Anax*, *Pantala*, *Tramea* are known as occupiers of new territories, being ubiquitous flyers and having special morphological features to support them during migration (Johansson et al. 2009). Specimens from all three genera were found within the investigated territory. The five *Tramea* specimens (Appendix 3) are supposed to belong to an endemic subspecies that possibly evolved on the island. *Anax* and *Pantala* are well distributed across the Pacific islands. No historical or molecular data are available to establish the time of their occupation on New Caledonia. However, their impact on local species is possibly negligible because they were found only in single localities, which were not in accordance with their typical habitat requirements. Both *Anax* and *Pantala* prefer standing water bodies and if they complete their life cycle within Mt. Panié, they possibly choose pools formed by the main rivers passing slowly through flat areas.

A monitoring program will also help to establish individual species' habitat preferences. It will not only increase knowledge about the ecology and biology of these interesting animal species, but could be used as a base for building special habitat models for the country, using GIS to incorporate habitat models with climatic trends, land use, and the geomorphological structure of the terrain. Habitat models may also predict other regions that are important to prioritise for future conservation actions. They could improve the global understanding of this poorly known study group and provide predictions about difficult to access sites or regions where field work is impossible, which seems to be the case in large areas around Mt. Panié.

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Appendix 1: List of odonate sampling locations during Mt. Panié RAP survey.

Initials in parentheses indicate which author sampled each locality

Primary sampling localities (MM):

1. Gite Ka Waboana. Hienghène (-20.6921; 164.9425; 0 m a.s.l.): 09 October.
2. Dané Yém river by the village of Bas Coulna (-20.6869; 164.7828; 188 m a.s.l.): 10 October.
3. Stream crossing the track Bas Coulna-Tamak area about 1.5 km NE from the village of Bas Counla (-20.6763; 164.793; 191 m a.s.l.): 10 October.
4. Lithotelm about 3.3 km NE from the village of Bas Coulna (-20.6603; 164.7966; 204 m a.s.l.): 10 October.
5. Stream crossing the track Bas Coulna-Tamak area about 4.0 km NE from the village of Bas Coulna (-20.6516; 164.7941; 188 m a.s.l.): 10 October.
6. Small creek flowing through a forested area about 4.5 km N-NE from the village of Bas Coulna (-20.6473; 164.7924; 296 m a.s.l.): 10 October.
7. Spring within the Tamak area (-20.6459; 164.8033; 140 m a.s.l.): 10 October.
8. La Guen river about 500 m before the mouth to Ouaième river (-20.6414; 164.8; 83 m a.s.l.): 11 October.
9. Stream passing near the RAP-New Caledonia Camp site 1 within the Tamak area (-20.6442; 164.7998; 147 m a.s.l.): 11 October.
10. Top of the ridge between RAP-New Caledonia Camp site 1 and refuge Blaffart (-20.6399; 164.7972; 280 m a.s.l.): 11 October.
11. Kompwara river below refuge Blaffart (right branch) (-20.6244; 164.7813; 560 m a.s.l.): 12 October.
12. Kompwara river below refuge Blaffart (left branch) (-20.6239; 164.7817; 522 m a.s.l.): 12 October.
13. Pool of the Kompwara river below refuge Blaffart (-20.6239; 164.7817; 510 m a.s.l.): 12 and 13 October.
14. Tributary of La Guen river flowing on the opposite slope of refuge Blaffart about 530 m from the bottom of the slope (-20.6191; 164.7808; 739 m a.s.l.): 13 October.
15. Tributary of La Guen river flowing on the opposite slope of refuge Blaffart about 700 m from the bottom of the slope (-20.6176; 164.7818; 756 m a.s.l.): 13 October.
16. Tributary of La Guen river flowing on the opposite slope of refuge Blaffart about 820 m from the bottom of the slope (-20.6165; 164.782; 760 m a.s.l.): 13 October.
17. Track on the ridge between refuge Blaffart and Gite Thao about 470 m NW from refuge Blaffart (-20.6263; 164.778; 706 m a.s.l.): 14 October.
18. Track on the ridge between refuge Blaffart and Gite Thao about 2.6 km NW from refuge Blaffart (-20.6161; 164.7602; 810 m a.s.l.): 14 October.
19. Track on the ridge between refuge Blaffart and Gite Thao about 3.2 km NW from refuge Blaffart (-20.6125; 164.7561; 886 m a.s.l.): 14 October.
20. Wé Djao stream crossing the track between refuge Blafart and Gite Thao about 4.3 km NW from refuge Blaffart (-20.6118; 164.7445; 472 m a.s.l.): 14 and 17 October.
21. Wewec river on the track between refuge Blafart and Gite Thao (-20.6151; 164.7354; 228 m a.s.l.): 14 and 17 October.
22. Pool by Wewec river on the track between refuge Blafart and Gite Thao about 840 m N from the place where river crosses the track (-20.608; 164.7326; 239 m a.s.l.): 14 October.
23. Pwé Teao river by Gite Thao (-20.6004; 164.7304; 310 m a.s.l.): 14–19 October.
24. Small creek flowing through densely vegetated area and entering Pwé Teao river by Gite Thao (-20.6004; 164.7304; 310 m a.s.l.): 15 October.
25. Pwé Teao river above Gite Thao (-20.5943; 164.7281; 324 m a.s.l.): 15 October.
26. Wewec river about 880 m downstream from Gite Thao (-20.608; 164.7326; 210 m a.s.l.): 15 October.
27. Pwé Tiera river about 1.2 km straight line NE from Gite Thao (-20.5916; 164.738; 265 m a.s.l.): 16 October.
28. Small spring by Pwé Tiera river about 1.2 km straight line NE from Gite Thao (-20.5916; 164.738; 265 m a.s.l.): 16 October.
29. Small spring by Pwé Tiera river about 1.3 km straight line NE from Gite Thao (-20.5898; 164.7368; 410 m a.s.l.): 16 October.
30. On the tack between refuge Blafart and Gite Thao. Left slope above the place where the river crosses the track (-20.6151; 164.7354; 160 m a.s.l.): 17 October.
31. Pwé Tiera river about 920 m straight line from Gite Thao (-20.5941; 164.7359; 168 m a.s.l.): 18 October.
32. Wewec river about 4.0 km downstream from Gite Thao (-20.6315; 164.7491; 108 m a.s.l.): 19 October.
33. Wewec river about 4.3 km downstream from Gite Thao (-20.6361; 164.7469; 55 m a.s.l.): 19 October.

34. Wan Pwé On river crossing the road Hienghène-Pouébo about 32.3 km NW of Hienghène (-20.4781; 164.7334; 0 m a.s.l.): 20 October.
35. Pwé Kédivin river crossing the road Hienghène-Pouébo about 10.4 km NW of Hienghène (-20.6325; 164.8645; 40 m a.s.l.): 21 October.
36. Small river crossing the road Hienghène-Pouébo about 20.5 km NW of Hienghène (-20.5592; 164.8056; 0 m a.s.l.): 21 October.
37. Small creek crossing the road Hienghène-Pouébo about 45.5 km NW of Hienghène (-20.4285; 164.6093; 20 m a.s.l.): 21 October.
38. Small creek crossing the road Hienghène-Pouébo about 21.2 km NW of Hienghène (-20.5569; 164.8006; 10 m a.s.l.): 21 October.

Additional sampling localities:

39. Roches de Wayem camp (-20.6397; 164.8711; 591 m a.s.l.): 1–5 November (SR).
40. Gite Thao (-20.5983; 164.7306; 359 m a.s.l.): 6–10 November (SR).
41. Dawenia camp (-20.5375; 164.6806; 586 m a.s.l.): 11–15 November (SR).
42. Mt. Ignambi, river (-20.4422; 164.6092; 580 m a.s.l.): 06 April 2003 (JT).
43. Mt. Ignambi, river (-20.4548; 164.5948; 1000 m a.s.l.): 08 April 2003 (JT).
44. Refuge Blaffart, creek (-20.5943; 164.7681; 1350 m a.s.l.): 12–13 January 2006 (JT).
45. Wewec river (-20.5972; 164.7302; 360 m a.s.l.): 16 November 2010 (JT).
46. La Guen, river (-20.6259; 164.7825; 600 m a.s.l.): 08 January 2006 (JT).

Appendix 2: Species checklist number and abundance per catchment and locality (primary sampling localities included only).

X indicates presence within each catchment.

Abundance categories within each locality: R (rare) – 1 to 4 individuals; 2) C (common) – 5 to 19 individuals; 3) A (abundant) – 20 to 99 individuals; and 4) VA (very abundant) – 100 to 499 individuals.

Catchment or locality	*Indolestes cheesmanae*	*Argiolestes ochraceus*	*Caledargiolestes uniseries*	*Caledopteryx sarasini*	*Trineuragrion percostale*	*Isosticta gracilior*	*Isosticta robustior*	*Isosticta spinipes*	*Isosticta tillyardi*	*Argiocnemis exsudans*	*Ischnura heterosticta*	*Anax gibbosulus*	*Oreaeschna dominatrix*	*Hemicordulia fidelis*	*Synthemis ariadne*	*Synthemis fenella*	*Synthemis miranda*	*Diplacodes haematodes*	*Orthetrum caledonicum*	*P. flavescens*	*R. phyllis*	*Tramea sp.*	Total species number
Dané Yém		x		x				x	x	x	x					x		x	x		x	x	11
La Guen		x		x		x	x	x		x				x		x		x	x				10
Wewec	x	x	x	x	x	x	x	x	x	x		x	x		x	x	x	x	x	x		x	19
Locality 1										R													1
Locality 2											A							A	C		R	R	5
Locality 3									R									C	C				3
Locality 4										C													1
Locality 5		R						C			R					R		R					5
Locality 6										R								R					2
Locality 7										C													1
Locality 8						R		R	R	C						R		R	R				7
Locality 9				R																			1
Locality 10																			R				1
Locality 11		C						A								R							3
Locality 12				C			R	A															3
Locality 13		R		C			R	C						R				A	A				7
Locality 14		R		R			R	C															4
Locality 15		R																					1
Locality 16		A		R																			2
Locality 17																			R				1
Locality 18															R								1
Locality 19																							0
Locality 20		C		A	A		C	C	R						R								7
Locality 21		R					R											C	C				4
Locality 22		R								A									C				3
Locality 23									C	A								VA	VA			C	5
Locality 24	1																						1
Locality 25								C	A							C							3
Locality 26		R			R		C		C							R	R						6
Locality 27				C			R	R	C			R				C							6
Locality 28			R					C															2

Catchment or locality	*Indolestes cheesmanae*	*Argiolestes ochraceus*	*Caledargiolestes uniseries*	*Caledopteryx sarasini*	*Trineuragrion percostale*	*Isosticta gracilior*	*Isosticta robustior*	*Isosticta spinipes*	*Isosticta tillyardi*	*Argiocnemis exsudans*	*Ischnura heterosticta*	*Anax gibbosulus*	*Oreaeschna dominatrix*	*Hemicordulia fidelis*	*Synthemis ariadne*	*Synthemis fenella*	*Synthemis miranda*	*Diplacodes haematodes*	*Orthetrum caledonicum*	*P. flavescens*	*R. phyllis*	*Tramea sp.*	Total species number
Locality 29		C	R	R	R			C															5
Locality 30													1										1
Locality 31						R																	1
Locality 32										C		R						A	A	R		R	6
Locality 33									C							R							2
Locality 34										R													1
Locality 35		R		R	R																		3
Locality 36										R													1
Locality 37				C					C									A	C				4
Locality 38		R								R													2

Appendix 3: Odonate species accounts for species observed during Mt. Panié RAP survey.

Each species encountered during the Mt. Panié RAP is presented with locality numbers corresponding to sites where they were collected (see Appendix 2). Short taxonomic notes are provided for clarification where necessary to justify the nomenclature adopted here. Biological and/or ecological information based on the RAP field studies is provided with brief details on species' national and global distribution status.

Lestidae

***Indolestes cheesmanae* (Kimmins, 1936)**

Localities: 24, 40.

This species' taxonomy still poses some uncertainties. It was originally described under *Austrolestes*. Lieftinck (1960) proposed subgeneric status as *Lestes* (*Indolestes*) *cheesmanae* and confirmed this view in Lieftinck (1975). Recently *Indolestes* is preferably given with a generic rank and used as such here.

The species is an inhabitant of streams running downhill through densely vegetated areas with 100% tree canopy cover, especially where the amount of water is much reduced or absent in sections forming shallow pools amongst the aquatic vegetation. No larva were found to check which sections of the actual stream are used. In the only description of the larvae by supposition Lieftinck (1960) does not state the type of habitat the larvae have been collected from.

I. cheesmanae is restricted to New Caledonia and Vanuatu.

Megapodagrionidae

***Argiolestes ochraceus* (Montrousier, 1864)**

Localities: 5, 11, 13, 14, 15, 16, 20, 21, 22, 26, 29, 35, 38, 39, 40, 41, 42, 43.

This species was observed in a variety of lotic habitats ranging from 2 to 24 m in width. In wider rivers they were recorded mainly as accidental species. The width of 10 m was the maximum where *A. ochraceus* was established as possibly breeding. Vegetation cover does not seem to play a significant role in adult choice for perching sites. Males were usually observed occupying twigs and leaves close to the banks, but also sitting on the top of stones exposed in the middle course of the rivers barely protected by the canopy.

A. ochraceus is endemic to New Caledonia. It is widely distributed throughout the country.

***Caledargiolestes uniseries* (Ris, 1915)**

Localities: 28, 29, 41, 43.

This small cryptic species was discovered in small (up to 2 m wide) creeks flowing on steep slopes with banks going almost vertically down the valley. It occurred at water depths from 1.5 to 20 cm, where trees completely covered the water and sunlight over the preferred perching places was much reduced. It was scarcely observed within the study area, and we found no clear evidence of breeding.

C. uniseries is endemic to New Caledonia, and has been recorded from all around the country.

***Caledopteryx sarasini* (Ris, 1915)**

Localities: 9, 12, 13, 14, 16, 20, 27, 29, 35, 37, 39, 40, 41, 42, 43, 44.

This species was encountered at various types of lotic biotopes ranging from 2 to 7 m in width. Possibly breeding individuals were mainly found close to waterfalls where they were choosing large rocks exposed to the sunlight as perching places. Twigs and leaves of the bank vegetation were occasionally used as well. Adults seemed to prefer sunlight even in places measured with vegetation cover of nearly 100%. Feeding was observed near pools of the main river preceding the waterfall. At those places adults could perch on stones just a few centimetres from the water edge with their head orientated towards the water surface. Prey was seized on the wing above the water and the individual quickly returned to the initial perching position while chewing. Three copulating pairs were observed, all of which selected stones by the waterfalls as perching substrates. On one occasion, we observed the entire mating following the initial grasp. The couple remained in this position for 17.8 minutes. The female left the spot quickly after separation and was not observed ovipositing.

C. sarasini is endemic to New Caledonia. It is confined mainly to the north of the country with Col de Nassirah as the southernmost point in its distribution known so far.

***Trineuragrion percostale* Ris, 1915**

Localities: 20, 26, 29, 35, 39, 40, 41, 42, 43.

This species is an inhabitant of moderate size rivers up to 5–6 m wide, where river banks were densely vegetated with the tree canopy ranging from 70% to 97%. Fallen tree trunks and branches in the middle course of the river were found to be of great importance. Copulating pairs (n=6) were observed perched on the trunks well above the water surface. The mating followed one general scheme with varieties observed in the duration of different stages. The couple stayed perched preferably on a dry branch or tree trunk bark (one occasion on a stone) usually for 2.50 to 4.30 minutes. One exceptionally long copulation took place for 114.35 minutes. After separation the partners always stayed perched (between 0.35–1.25 minutes) with the female behind the male holding their abdomens parallel to each other. Oviposition took place on the tree trunk, again just a few millimetres above the water surface. The female laid eggs alone while the male stayed up to 55 cm away facing her. We did not observe any other potential rivals within this territory in order to test whether the male was guarding his partner from a distance. We observed the male mating with other females which happened to pass through the place. The longest oviposition lasted for 143.35 minutes. A teneral female individual with its exuviae was observed on the same oviposition substrate.

On one occasion, exuviae were found in a river more than 20 m wide. They were exposed on boulders about 1 m from the bank inside the river. These exuviae were identified based on the teneral female with its exuviae described above.

T. percostale is confined in its distribution to New Caledonia and Vanuatu.

Isostictidae

***Isosticta gracilior* Lieftinck, 1975**

Localities: 8, 31.

Teneral individuals were collected only from some of the largest rivers within the region (13–30 m wide). In both localities, adults were observed sitting on the top of large boulders close to the bank of the river under a canopy cover of up to 87%. Unidentified larvae from locality 8 possibly belong to this species. Larvae of this species have never been described and the determination here is based on the wing venation visible from the wing-sheaths.

I. gracilior is endemic to New Caledonia, and has so far been reported only from the southern part of the country.

***Isosticta humilior* Lieftinck, 1975**

Localities: 44.

One dead teneral specimen was found on a *Pandanus* sp. leaf near the Wewec river.

I. humilior is endemic to New Caledonia and is known from only 11 localities.

***Isosticta robustior* Ris, 1915**

Localities: 12, 13, 14, 20 (17 October), 21 (17 October), 26, 27, 39, 41.

This species was recorded as breeding in the study area due to exuviae discovered in streams and rivers of varying size (6.5–24 m wide and 10.6–21.4 cm deep) and stream velocity (70 to 171 cm/s). Emerging individuals were collected inside river beds on exposed boulders with no tree canopy above. All had selected sites on the rocks that were well protected from eventual flushes and direct sunlight. Near shore boulders were primarily chosen as a substrate for emergence, but individuals were also observed in the middle of rivers. The vegetation cover was between 34–59% close to the banks. Adults were encountered in shady rivers also, but always at places with increased insolation.

I. robustior is endemic to New Caledonia. It is widely distributed on the main island and is also reported from Lifou Island, Loyalty Islands (Ris 1915).

***Isosticta spinipes* Selys, 1885**

Localities: 5, 8, 11, 12, 13, 14, 20, 25, 27, 28, 29, 39, 40, 41.

This species was observed predominantly in shady places with vegetation cover ranging between 90–100%. Adults were found mainly along rivers 6 to 10 m wide, but teneral individuals were collected from a river about 30 wide. Although encountered at many places in Mt. Panié, only one record was made of a breeding individual. We are confident that the species is reproducing at other sites within the study area, although more data are necessary to obtain a better understanding of its environmental preferences

I. spinipes is endemic to New Caledonia, where it is mostly reported from observations of single individuals from the north and south of the main island and also from Lifou Island, Loyalty Islands (Ris 1915). Due to the relatively high local abundance we observed for the species during this RAP, we believe its apparent rarity may be due to the fact that the species has been overlooked in its specialized habitat. Further study may reveal a broader distribution.

***Isosticta tillyardi* Campion, 1921**

Localities: 3, 8, 20, 23, 25, 26, 27, 33, 37, 40.

This species was generally found in streams and rivers with less vegetation cover (59–87%). Adults were collected from more densely vegetated areas (up to 99%), but we consider it as accidental at these sites. *I. tillyardi* was observed flying above the midsections of the streams and even near some stretches with no visual surface flow. However, we did not find any evidence of reproduction in these parts of the river. Exuviae were found along fast flowing sections of the river with stream velocity of 160 cm/s.

I. tillyardi is endemic to New Caledonia and is distributed throughout the country.

Coenagrionidae

***Agriocnemis exsudans* Selys, 1877**

Localities: 1, 4, 6, 7, 8, 22, 23, 32, 34, 36, 38, 40, 44, 45.

This species prefers standing or slowly moving waters. It is a typical inhabitant of oxbow lakes, densely vegetated pools and backwaters formed by the floods along the river banks or inside the main stem of the river. Shady springs flowing through forested areas and lithotelms well exposed to the sunlight constituted other biotope types for this species. Submerged aquatic vegetation seems to be an important feature that determines the presence of *A. exsudans* within the study area. Exuviae and mating pairs were observed among the low growing stems just above the water surface.

A. exsudans is widely distributed across the Pacific from New Caledonia to Tonga. It is commonly reported from all over New Caledonia including Ouvea Island, Loyalty Islands (Lieftinck 1976, Bigot 1985).

***Ischnura heterosticta* (Burmeister, 1839)**

Localities: 2, 5, 45.

This species usually inhabits stagnant waters, but probably also develops in vegetated pools formed inside the main river stem or backwaters by the banks. It was rarely encountered within the study area, with only locality 2 established as typical *I. heterosticta* habitat and where the species was confirmed to breed.

I. heterosticta is widely distributed across the Pacific ranging from New Caledonia and Australia to Tonga. It is commonly reported from all over New Caledonia including Ouvéa Island, Loyalty Islands (Lieftinck 1976, Bigot 1985).

Aeshnidae

***Anax gibbosulus* Rambur, 1842**

Localities: 27, 32, 40.

Individuals from the same genus were recorded in flight in localities 2, 21 and 35, but could not be identified. As there are two species reported for the country (Davies 2002) and both are powerful fliers, further information is needed to confirm which species inhabits these additional three localities.

A. gibbosulus was recorded within the study area by males only, which could be just accidental visitors. On both occasions they were discovered close to fast flowing large rivers up to 24 m wide. Two of them were flying at a height of about 2 m above the water surface, which represent feeding behaviour. More investigation is needed to confirm whether this species is a regular inhabitant of these biotopes, especially since species from the genus are typical of standing water bodies.

A. gibbosulus occurs in Australia, Moluccas, Samoa and French Polynesia. Davies (2002) reports it as common all through the season, but it was reported only twice by other explorers of New Caledonia (Lieftinck 1975, Karube 2000).

***Oreaeschna dominatrix* Vick & Davis, 1990**

Localities: 30, 40.

Only one accidental male was collected from the entire study area. Previous data (Vick & Davies 1990, Karube 2000, Davies 2002) report it as a frequent inhabitant of mountainous regions,which suggests that *O. dominatrix* could be widely distributed across Mt. Panié. Further research is needed to assess its actual status within the area.

O. dominatrix is endemic to New Caledonia and is reported for Lifou, Loyalty Islands (Vick & Davies 1990). It is perhaps more widely distributed than presently known, as most of the current records come from unpublished data.

Corduliidae

***Hemicordulia fidelis* McLachlan, 1886**

Localities: 13 (12 October), 39, 40.

This species was recorded as possibly breeding within the study area. A female ovipositing about 1.5 m from the bank was observed in a pool section of the river with gravelly bottom.

H. fidelis is restricted to New Caledonia and Vanuatu. It is commonly observed in New Caledonia.

***Synthemis ariadne* Lieftinck, 1975**

Localities: 18, 20 (17 October), 39, 40.

One teneral male was discovered at locality 20. It took off the ground in the same manner typical of individuals performing their maiden flight. Although no exuviae were found, we consider the species to be breeding at this site. The female encountered at locality 18 suggests that adults may fly up to 1,700 m from their breeding sites and ascend 400 m to hill tops.

Another *Synthemis* individual was recorded at locality 19, but not caught. Based on the proximity of this site to the other two localities where *S. ariadne* was observed, this individual probably represents *S. ariadne*.

S. ariadne is endemic to New Caledonia. It has been reported from the north and south, although only single individuals have been observed.

***Synthemis fenella* Campion, 1921**

Localities: 5, 8, 11, 25, 26, 27, 33, 39, 40, 41, 44.

This species was typical of rivers with large exposed boulders at the mid-sections. Adults used these boulders as perching sites with no preferences observed for sunny versus shady areas. The fact that they were mainly observed at the middle of the river suggests a tendency towards sunny substrates, although this conclusion should be further tested. Although many individuals were found during the study, only three exuviae were collected, indicating that the species is breeding at localities 8, 26 and 33. For the moment it is considered as possibly breeding at locality 11.

S. fenella is endemic to New Caledonia and is widely distributed throughout the country.

***Synthemis miranda* Selys, 1871**

Localities: 26, 39, 40, 41.

We observed breeding individuals of this species at a large river (about 20 m wide) with large boulders across the whole width. A teneral male with its exuviae were attached to one of the boulders situated about 1 m from the bank. Larvae were also collected from the same site.

S. miranda is endemic to New Caledonia. It is commonly encountered throughout the country.

Libellulidae

***Diplacodes haematodes* (Burmeister, 1839)**

Localities: 2, 3, 5, 6, 8, 13, 21 (17 October), 23, 32, 37, 40, 44, 45, 46.

This species was observed predominantly within the sunny sections of rivers on boulders and bed rocks. Adults showed no preference to the particular position of their perching substrate; either rocks inside or along the bank of the rivers were chosen as long as they received enough sunlight. Vegetation seems to be of secondary importance, if any, for *D. haematodes* along flowing waters. These places were occupied by males or mating pairs. Females were mainly encountered away from the water. Females arrived along the rivers females only for mating and ovipositing.

D. haematodes ranges from Australia to New Guinea, and reaches Vanuatu to the east. It is among the most common species in New Caledonia.

***Orthetrum caledonicum* (Brauer, 1865)**

Localities: 2, 3, 8, 10, 13, 17, 21, 22, 23, 32, 37, 40, 44.

This species inhabited the same type of habitats described for *D. haematodes*. Both species were commonly encountered together. Their activity appears to depends on sunlight and air temperature. Adults stayed inactive until their preferred spots were totally insolated and the temperature rose above 20oC.

O. caledonicum is reported also from Australia and New Guinea. Along with *D. Haematodes,* it is one of the most common species for New Caledonia.

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

Localities: 32.

The single observation reported here comes from a flying individual passing through the locality. For the moment it is considered as an accidental species for Mt. Panié.

P. flavescens is a cosmopolitan species. It is widely distributed in New Caledonia and possibly will be confirmed as breeding within Mt. Panié.

Rhyothemis phyllis **(Sulzer, 1776)**
Localities: 2.

The individual we observed probably belong to *R. p. apicalis* Kirby, 1889, which is found throughout the country. Since we only observed a single individual from a distance, we cannot be certain about subspecies identification.

R. phyllis is a species with wide distribution across the Pacific, SE Asia and Australia. It is represented by various subspecies across its range, with *R. p. apicalis* endemic to New Caledonia.

Tramea **sp.**
Localities: 2, 23, 32, 40.

We collected 5 specimens from the four localities listed above. Species identification is difficult due to taxonomic uncertainties. Four of the specimens have features that match well with the description of Lieftinck (1975) for *T. transmarina intersecta*. The fifth specimen differs from the others by the intensity of the dark area at the base of the hind wings, but not by any other morphological characters that we could determine. Four *Tramea* species have been reported for the country Given the high variability of species in the genus *Tramea* and lots of synonyms already introduced in the literature, it is preferable at this stage to refer to the specimens from this study with their genus name only. , with *T. t. intersecta* also elevated to species status (*T. Intersecta)*. Davies (2002) elevates *T. t. intersecta* to species status (*T. intersecta*), but does not provide any taxonomic studies to support this decision. Further molecular analysis is required to resolve taxonomic uncertainties within the genus *Tramea*.