Faunistic Studies in South-East Asian and Pacific Island Odonata

Journal of the International Dragonfly Fund

ISSN 2195-4534

Content

Volume 5 2013

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Internet: http://www.dragonflyfund.org/

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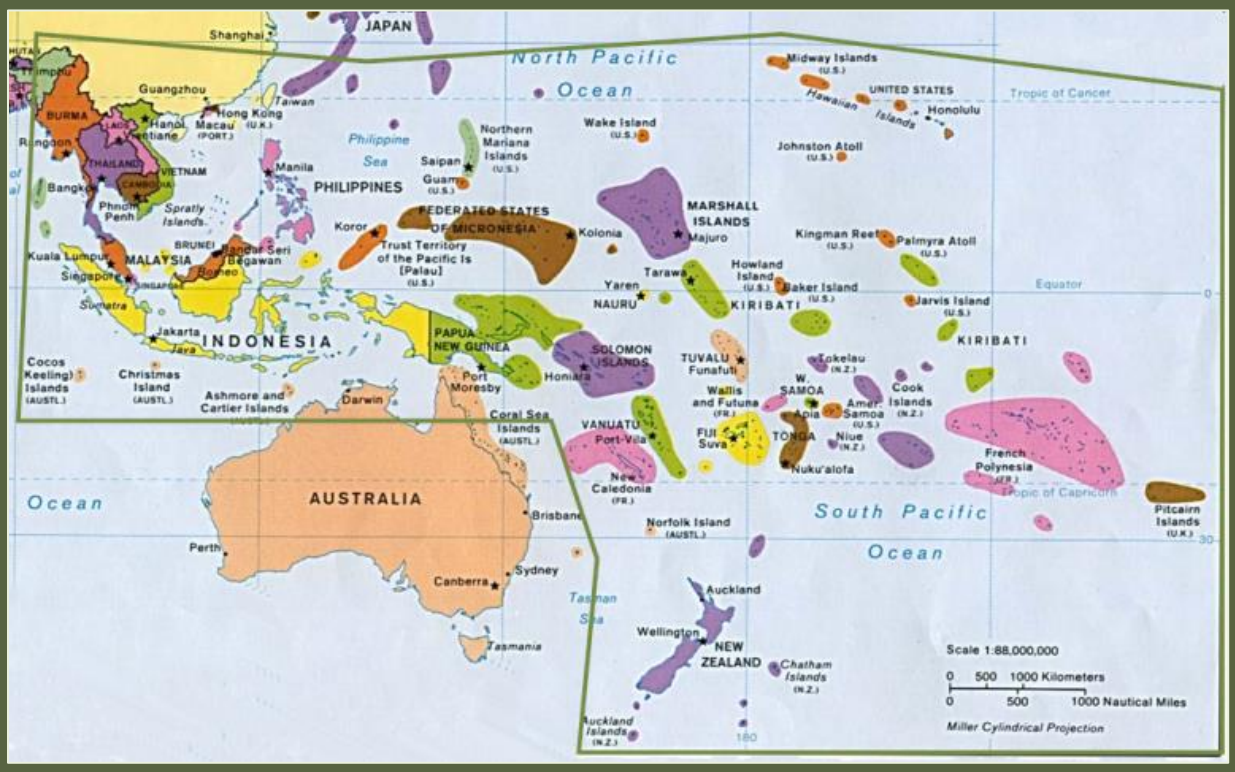
Pacific Islands comprise of Micronesian, Melanesian and Polynesian Islands.



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Editorial Work: Rory Dow, Milen Marinov, Graham Reels and Martin Schorr

Layout: Martin Schorr

Indexed by Zoological Record, Thomson Reuters, UK

Printing: ikt Trier, Germany

Impressum: Faunistic Studies in South-East Asian and Pacific Island Odonata - Volume 03

- Date of publication: 19.08.2013
- Publisher: International Dragonfly Fund e.V., Schulstr. 7B, 54314 Zerf, Germany. E-mail: oestlap@online.de
- Responsible editor: Martin Schorr

A revised and updated Odonata checklist of Samoa (Insecta: Odonata)

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Abstract

Odonata records of the Samoan Archipelago are updated and an updated checklist provided. It is part of an ongoing assessment of the fauna, taxonomy and distribution of the Pacific island dragonflies. The checklist follows recent reviews published/prepared about the Solomon Islands, New Caledonia, Fiji and Kingdom of Tonga.

This study draws on recent dragonfly records following general insect surveys spanning 2008-2012 funded by Critical Ecosystem Partnership Fund (CEPF) via Conservation International (CI) to the authors and to Secretariat Pacific Regional Environment Program (SPREP) and also by funding from Japan International Cooperation Agency (JICA). Other unpublished data from Samoan Archipelago and Niue are included as well. All, but one, of the newly collected Odonata species are widespread within the Pacific region. *Hemicordulia cupricolor* is the only species from the recent collections which is endemic to Samoa, previously reported for Savai'i and Upolu Islands. It has never been confirmed since its original description in 1927. The new study shows the species as an inhabitant of high altitude zones of Savai'i. It is recommended inland areas of Savai'i and other islands within the Samoan Archipelago should be targeted in further field studies.

Keywords: Samoan Archipelago, Samoa, Niue, *Hemicordulia cupricolor*, Savai'i

Introduction

Studies on the Pacific Odonata in recent years have been revived due to continuous samples within the region that resulted in a series of publications (Marinov 2011, 2012a,b, 2013; Marinov & Theischinger 2012; Marinov & Donnelly 2013). Those studies focused on various aspects of taxonomy, fauna and biogeography of the Pacific odonates and made important contributions towards understanding contemporary species composition, distribution pattern within and between oceanic archipelagos as well as species ecology and behaviour. All achievements were possible thanks to the database compiled for the vast region outlined in Marinov & Docher (2011), which allows for an easy retrieval of all data ever published. The latter were used for effective planning of future research on the group within the region which resulted in description of new to science taxa (Marinov 2012a; Marinov & Theischinger 2012; Marinov & Donnelly 2013).

The reference lists compiled for specific archipelagos were another important aspects of those studies. They integrated the already published data with the new collected material and considered the contemporary taxonomy in order to provide updated species check lists for Fiji (Marinov 2011), Kingdom of Tonga (2012a), New Caledonia (Grand et al. in press) and Solomon Islands (Marinov & Pikacha 2013). Considering the importance of such lists the focus of the literature, data compilation and analysis expanded to include other parts of the Pacific.

A small Odonata collection recently obtained from the Samoan Archipelago sparked the current review on the local fauna. It complements the last evaluation of Samoan odonates (Donnelly 1986) and includes every record entered into the Pacific Odonata database. It is important to note that the Odonata literature review encompasses the Samoan Archipelago as a geographic structure and does not consider the political borders, which have been influenced by continuous debates between several nations. To avoid a further confusion a short clarification of the historical involvement of the various countries over the Samoan Archipelago is presented here.

Short history of the Samoan Islands

Originally termed the Navigators Islands by European discoverers from the 17th century onwards, alluding to the sailing skill of the locals, the Samoan Archipelago has had a turbulent history. Following years of conflict in two civil wars aided by the colonial powers of Germany, United kingdom and United States, the Samoan islands were partitioned in 1899-1900 into a German Samoa covering the large islands of Savai'i and 'Upolu and an American unincorporated territory of the much smaller islands of the eastern end of the archipelago including Tutuila and Ta'u. At the outbreak of World War I, Britain encouraged New Zealand forces to take the German territory. This area eventually came under New Zealand's jurisdiction as Western Samoa. In 1962 it was the first South Pacific nation to gain independence and by 1997 had changed its name to the Independent State of Samoa.

This paper uses neither of these country names. Table I instead lists the odonate species in chronological order as they have been discovered for the entire Samoan Archipelago. Each species is represented with the original published species name followed by the currently accepted one, verbatim locality name, literature source and page. Species new to science described from Samoan islands are marked with **"*"**.

Taxonomic history of Odonata species

In four consecutive publications Brauer (1867a, b; 1868; 1869) introduced the first odonate species recorded. A total of seven taxa were reported (three as new to science), but only six of them are included in Table I. Ris (1909-1919) synonymised the seventh species *Tramea samoensis* Brauer, 1867 with *Tramea transmarina* Brauer, 1867. Since *T. transmarina* was originally described from Fiji, two of Brauer's taxa are marked in Table I as new to science described from Samoa.

More information about Samoan *Tramea* is to be found in Ris (1909-1919). He included previously reported *samoensis* and *transmarina* under *T. limbata* (Desjardins, 1832) and reported additional specimens of the same species. *T. limbata* is a very wide spread species reported from both Indian and Pacific oceans, however its status within the Pacific remains unclear (Marinov 2013) and thus excluded from Table I. Ris (1909-1919) reported five more species with two new to Samoa.

Frederick Charles Fraser comes next chronologically. He is by far the greatest contributor to the Samoan Odonata. Although published about 90 years ago his papers (Fraser 1925, 1926, 1927) are a real inspiration for every researcher of the Pacific islands Odonata. A special admiration must also be given to the collectors who provided the material for those studies: Dr. J. S. Armstrong, Dr. P. A. Buxton, Mr G. H. E. Hopkins and Mr E. H. Bryan with some others not specified by the author. One of them (Dr. Armstrong) continued to supply Fraser with material from Apia. His collections were summarised in Fraser (1953). In some aspects Fraser's contributions have also significant historical importance alongside his work on the taxonomy and fauna of the group within the Samoan Archipelago. A range of species from the so called "Ischnurinae complex" (Fraser 1953) remained without confirmation in spite of the careful observation in more recent times (Donnelly 1986). This subject is treated with special attention in the 'Discussion part' below. Here is a summary of Fraser's major achievements.

All three papers published in mid-twenties increased significantly the number of odonates known from this Pacific region. At the end of this period Fraser (1927) claimed 29 species as inhabitants of Samoan Archipelago, however, he provided a list with 28 species names. Not all of them are included here in Table I. *Agriocnemis vitiensis* Tillyard, 1924 was synonymised with *A. exsudans* Selys, 1877 (which was discussed by Fraser himself who finally left those two as separate species), *Rhyothemis regia exul* Ris, 1913 is omitted following the discussion provided in Lieftinck (1959), *Tramea*

limbata is replaced with *T. transmarina* (following the suggestion of Marinov 2013) and *Hemicordulia oceanica* Selys, 1871 is excluded following the note in the literature review in Marinov & Pikacha (2013). That brings all together 26 species reported for Samoa at mid-twenties. Two more new to science species were published in Fraser (1953) who also described females of already known species.

The Odonata literature after Fraser's contributions contains hardly any new data on Samoan species. In fact with one exception only (Donnelly 1986) no additional field sampling specially featuring Odonata of Samoan Archipelago has been published. Samoan odonates were mentioned with references to Fraser's studies (Buxton 1927; Endersby 2002), during taxonomic discussion (Fraser 1956; Lieftinck 1959) or short distribution notes on previously recorded species (Schmidt 1941; Watson 1984; Donnelly 1987). In fact Watson (1984) associated old records from Samoan Archipelago of *Orthetrum sabina* Drury, 1770 (first recorded by Fraser (1927)) with *O. serapia* Watson, 1984, a new species erected by him and which is included in Table I.

Donnelly (1986) and Dommanget & Mashaal (2000) provided collectively the last two new species to Samoa which bring the total number of species for the Samoan Archipelago up to 30. At least two more new taxa were reported in the literature, but have not been described yet. Donnelly (1986) had *Amorphostigma* sp. nov. and *Pacificagrion* sp. nov. in his collection from Tutuila Island. The latter taxa is recalled in Donnelly (1995). Their description was not given in the original publication and is still pending.

Donnelly (1986) provided important general characteristics of the islands in terms of Odonata habitat availability, taxonomic discussions on the validity of Fraser (1927)'s "*Ischnura* complex", correct position of *Pericnemis annulata* Fraser, 1927 and faunistic records on genus *Anax* for Samoa. He concluded that *Ischnura* from Samoa must be assigned to a different genus. He also followed Lieftinck (1959) who proposed *P. annualata* to be regarded as member of *Nesobasis* being closely related to *N. flavalabris* Selys, 1891 and probably conspecific to it. The Samoan taxon, however, is placed here under another generic name *Melanesobasis* which was proposed by Donnelly (1984) for seven species inhabitants of Fiji and Vanuatu. It is with agreement with Donnelly (1986) who also suggested that the type of *M. annulata* may have been mislabelled, but was reluctant to continue further with this point as the type specimen was in a very poor condition. *M. annulata* remains in the Samoan Odonata check-list until additional material unquestionably proves otherwise.

In the other paper of the same author Donnelly (1995) emphasised on a curious case of Zygoptera larvae living in a thin rock fissure underneath the basal rocks briefly described earlier in Donnelly (1986).

The literature review shows that Samoan Archipelago has been largely inconsistently studied with great gaps in the research between the field samplings. The present

paper makes a small contribution to the faunal species list. Its main purpose is to summarise the data and to encourage the research within the archipelago by showing how a small sample could bring important taxonomic and faunistic discussions.

Material and Methods

Samoan Archipelago (Fig. 1) was visited in relation to butterfly studies 2008, 2009, 2010 and in relation to an upland biodiversity resources survey (BIORAP) of Savai'i Island in 2012. The survey was organised by the SPREP a multi-agency pacific biodiversity group, based in Apia, Samoa. Survey specialists included botanists, herpetologists, avicologists and entomologists from several countries and organisations. The survey was organised by James Atherton and Bruce Jefferies of Apia, Samoa, and the results will be used for conservation management between local communities, government and international agencies. Additional unpublished data from Upolu Island was included as well. It results from three events: Eric Edwards contract with JICA / MNRE to do insect survey of National Park on Upolu 2008; Brian & Hamish Patrick

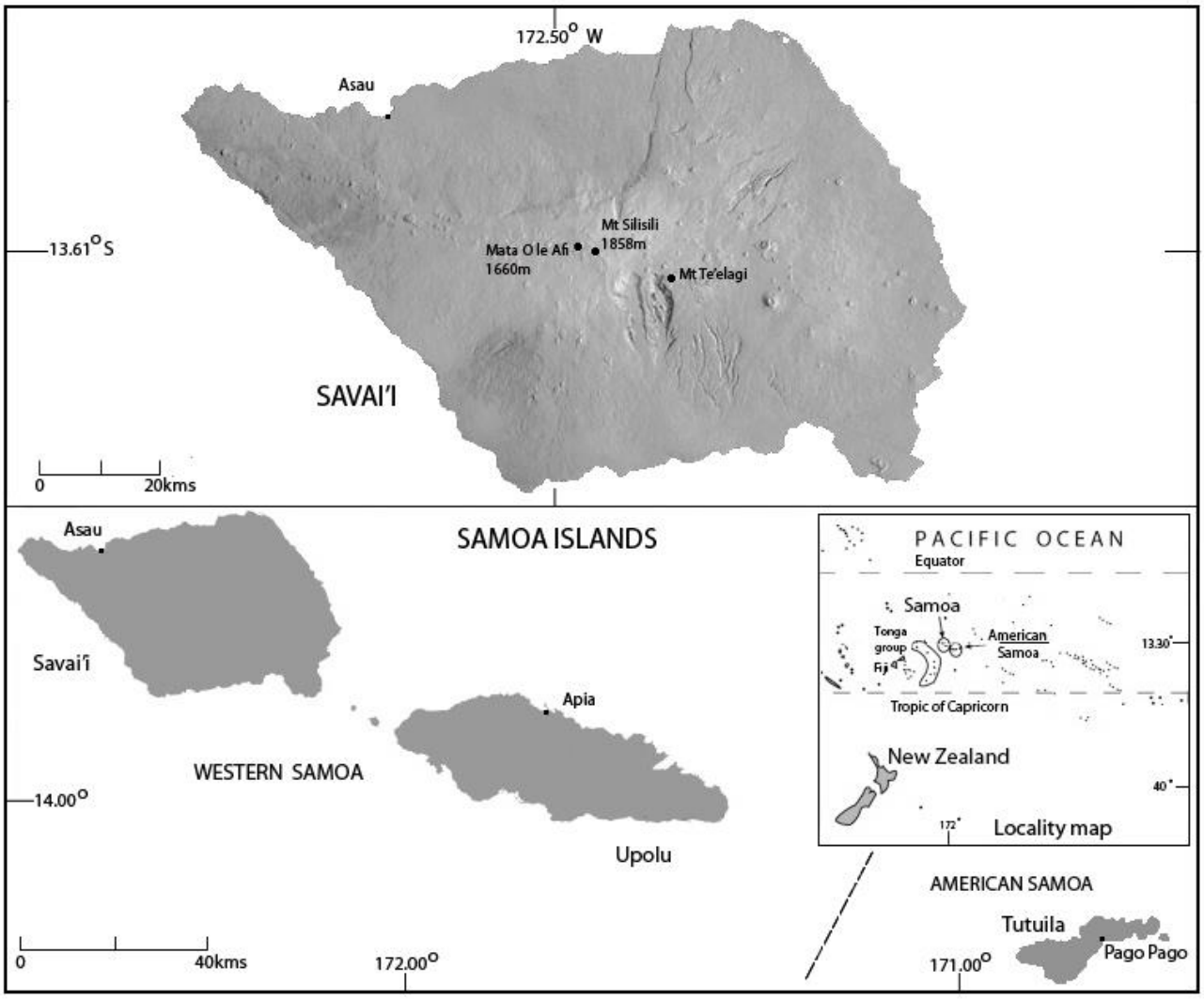

Figure 1. Geographic location of Samoan Archipelago.

assisting him but also travelling to Tutuila Island in 2008; and CEPF/CI funded Samoan swallowtail project 2009-2010 to Samoan Archipelago.

Odonata specimens were collected from all main islands within the Samoan Archipelago (Fig. 2). Specimens were collected with sweep nets, killed by freezing or using ethyl acetate, dried and pinned at room temperature. Specimens will be deposited in both New Zealand Arthropod Collection (NZAC –Auckland) and Lincoln University Entomology Research Museum (LUNZ).

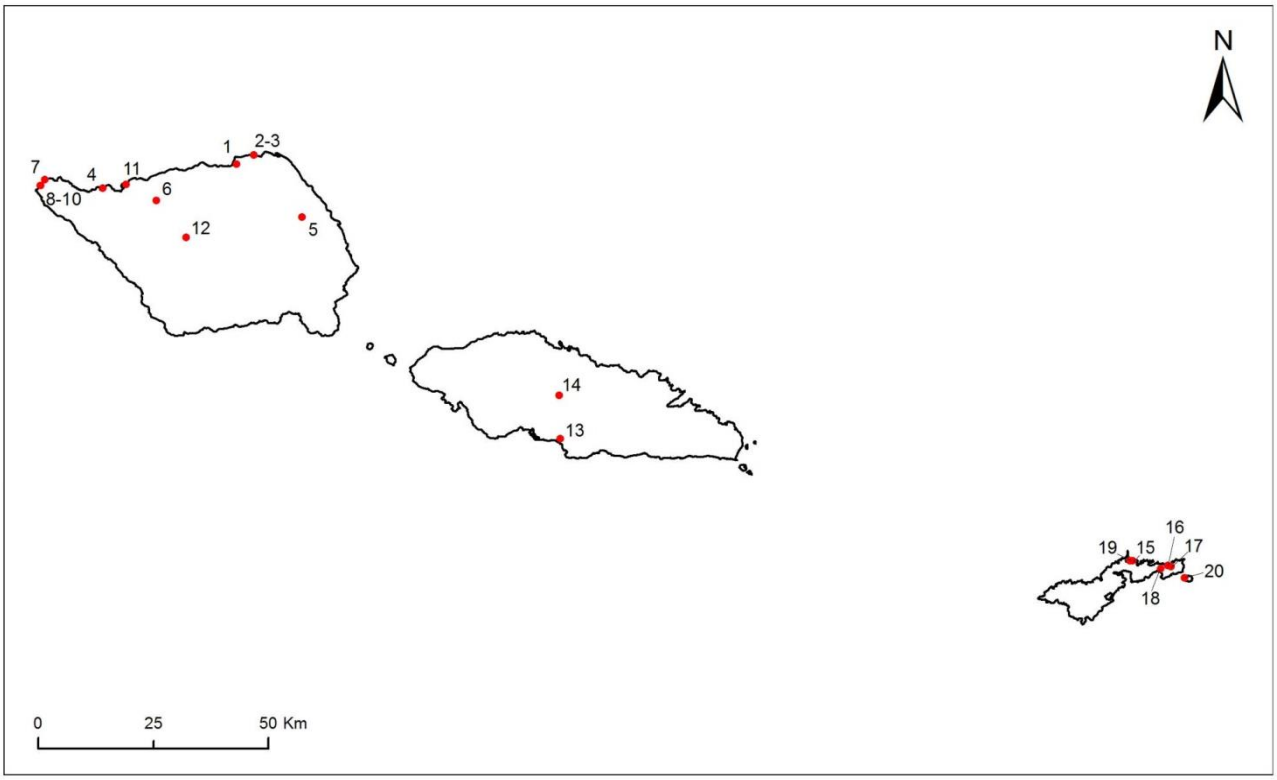

Figure 2. Odonata sampling sites of Samoan Archipelago.

Species identification was based on the existing morphological descriptions and already collected material from various parts of the Pacific. In one occasion only the new material was compared to the type series. That was made possible thanks to the courtesy of Dr. Benjamin Price, who provided high resolution images subject to a creative commons license (CC BY-NC 3.0) with attribution to The Natural History Museum, London.

Microscopic pictures for the figures (Figure 3-6) were produced using the Plant Health and Environment Laboratory, Christchurch, Ministry for Primary Industries equipment. Series of images were taken under high power Nikon AZ100M microscope and stacked with Helicon Focus 5.3 software.

Below is a list of Odonata sample sites and the initials of the collectors given in brackets. Collectors' full names are as follows: Alex, Hamish and Tesca Edwards (AHTE), Brian Patrick (BP), Czarina Iese (CI), Eric Edwards (EE), Lainey Berry (LB), Sandra, Alex and

Hamish Edwards (SAHE), Stephen Turnbull (ST), Tesca Edwards (TE), Tone Simanu & Joe Pisi (TSJP), Tavita Togia (TT), Warren Chinn (WC), Warren Joplin (WJ).

Savai'i Island

1. Matavanu larvaflow (13.464589° S, 172.410336° W; 50 m a.s.l.): 09 March 2008 (EE & WJ leg.)
2. Manase (13.446767° S, 172.377334° W; 2 m a.s.l.): 13 March 2008 (EE leg.)
3. Manase (13.446767° S, 172.377334° W; 5 m a.s.l.): 23-25 March 2010 (AHTE & EE leg.)
4. Vaisala (13.51162° S, 172.672291° W; 20 m a.s.l.): 13 April 2009 (EE & BP leg.)
5. Tagotala quarry (13.569239° S, 172.282877° W; 240 m a.s.l.): 12 March 2010 (EE, TSJP, CI, LB & ST leg.)
6. A'opo Rd (13.536447° S, 172.566977° W; 180 m a.s.l.): 24 March 2010 (EE, SE & TE leg.)
7. Cape Vaitola (13.494637° S, 172.785244° W; 2 m a.s.l.): 24 March 2010 (TE leg.)
8. Asau, coastal vegetation, C46 (13.5070° S, 172.7937° W; 0 m a.s.l.): 18 May 2012 (EE & WC leg.)
9. Shrublands, C47 (13.5070° S, 172.7937° W; 514 m a.s.l.): 18 May 2012 (EE & WC leg.)
10. Falealupo, C48 (13.5070° S, 172.7937° W; 0 m a.s.l.): 18 May 2012 (EE & WC leg.)
11. Asau, airstrip, C49 (13.5046° S, 172.6266° W; 0 m a.s.l.): 18 May 2012 (EE & WC leg.)
12. Shrublands/fellfield (13.6089° S, 172.5094° W; 1636 m a.s.l.): 30 May 2012 (EE & WC leg.)

Upolu Island

13. Southern coast, central area (14.0069° S, 171.7785° W; 5 m a.s.l.): 17 September 2008 (BP, HP leg.)
14. Western cross island road (13.9212° S, 171.7810° W; 335 m a.s.l.): 17 September 2008(BP, HP leg.)

Tutuila Island

15. Sauma (14.248744° S, 170.661449° W; 100 m a.s.l.): 07 April 2009 (EE, SAHE & TE leg.)
16. Sa'ilele-Motusaga Pt (14.258061° S, 170.592098° W; 5 m a.s.l.): 19 March 2010 (EE, TT & ST leg.)
17. Aoa Bay (14.260806° S, 170.585661° W; 5 m a.s.l.): 19 March 2010 (EE, TT & ST leg.)

18. Mt Pioa Pass (14.264258° S, 170.606174° W; 265 m a.s.l.): 21 March 2010 (EE, SAHE & TE leg.)
19. Sauma Ridge (14.248453° S, 170.666127° W; 25 m a.s.l.): 21 March 2010 (EE, BP & TT leg.)

Aunu'u Island

20. Aunu'u Island (14.283099° S, 170.559955° W; 2 m a.s.l.): 20 March 2010 (AH-TE & EE leg.)

Results

A total of 36 specimens belonging to ten species have been collected. They are given below with a reference to the locality number and the sex.

AESHNIDAE

1. *Anaciaeschna jaspidea* (Burmeister, 1839)
   Localities: 3 (1♀, 1♂ 23 March; 1♀ 25 March)
   The male specimen resembles *Anaciaeschna melanosoma* Lieftinck, 1949 in having intensively developed dark purple area on the frons which descends towards the dorsal edge of postclypeus and diffusing on the surface of postclypeus. Figure 3 compares this specimen to what is considered as typical colouration of the male *jaspidea*. Figure 4 shows male appendages of both *jaspidea* and *melanostoma* (based on the drawings from the original description). Note the great similarity in the general view between the two species. The narrow and slightly elongated bases of *melanostoma* is the only significant diagnostic feature that could be pointed out.

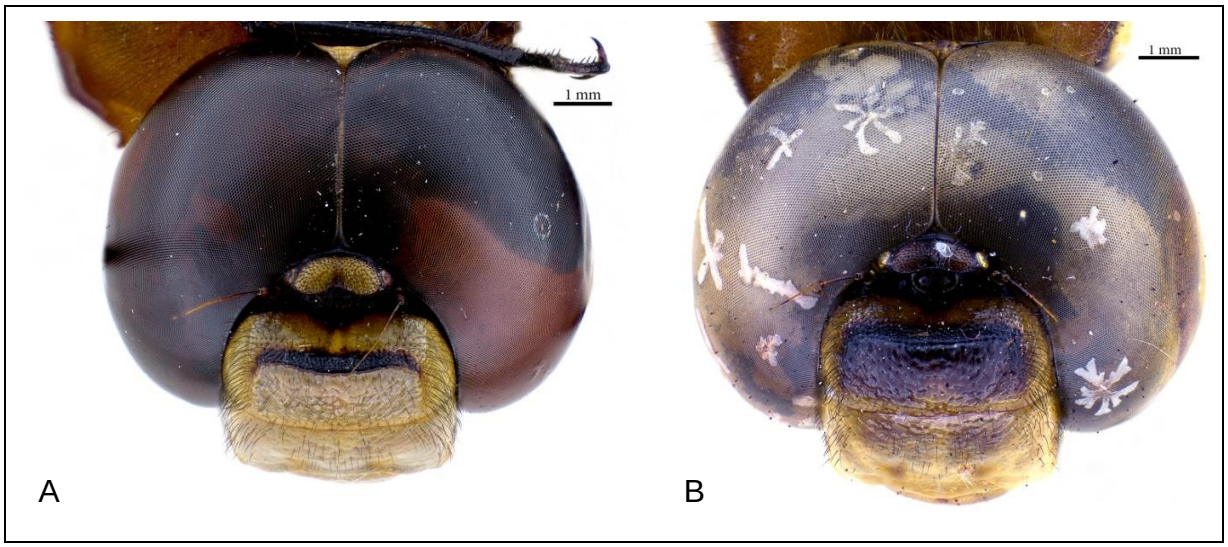

Figure 3. Comparison between faces of *Anaciaeschna jaspidea* from: a) Kingdom of Tonga (Marinov 2012a), and b) Samoa (this paper).

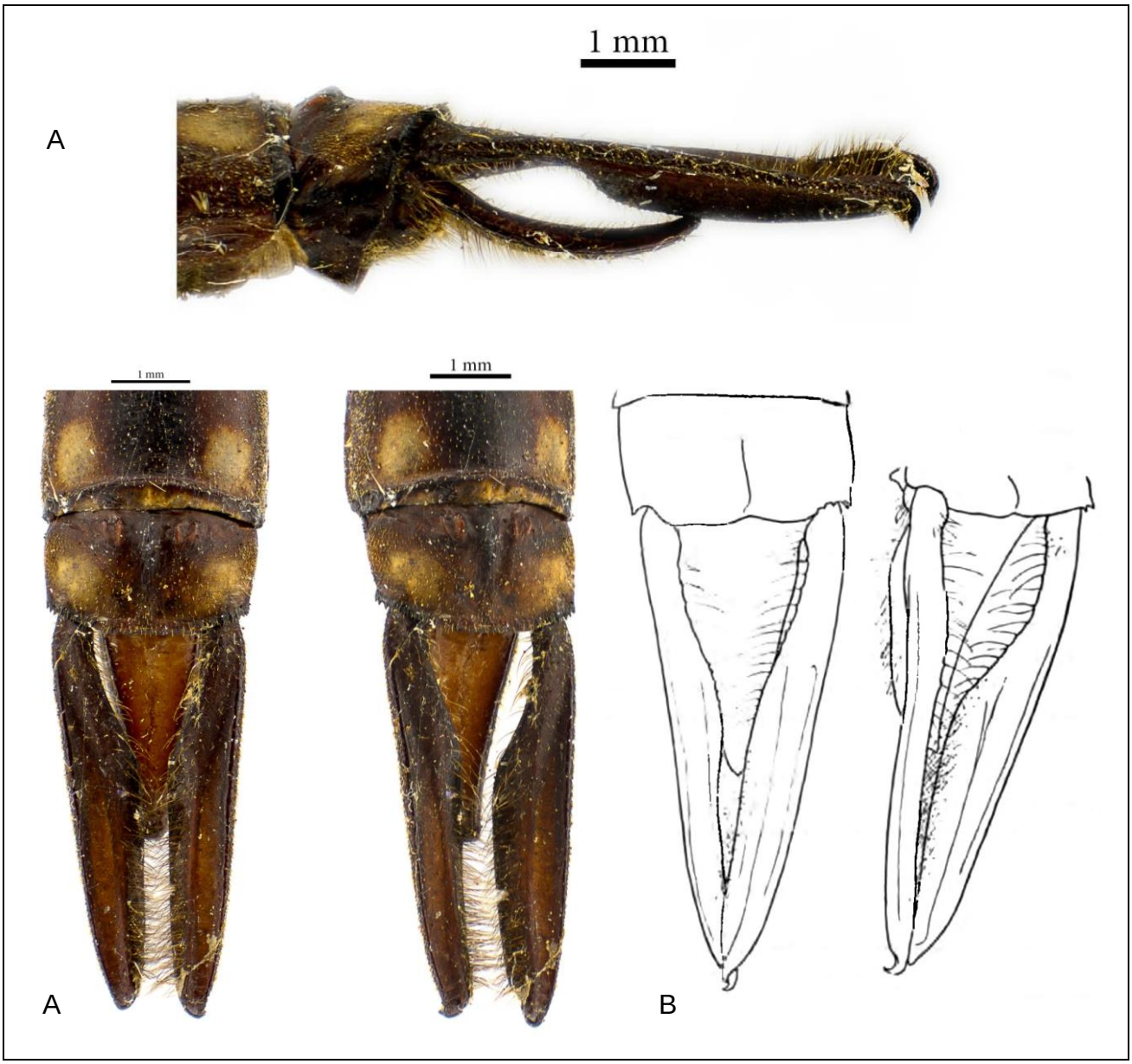

Figure 4. Comparison between the appendages of: a) *Anaciaeschna jaspidea*, Kingdom of Tonga (Marinov 2012a), and b) *Anaciaeschna melanostoma*, Solomon Islands (Lieftinck 1949).

2. *Anax guttatus* (Burmeister, 1839)
   Locality: 4 (1♀)

CORDULIIDAE

3. *Hemicordulia cupricolor* Fraser, 1927
   Locality: 12 (1♀)
   This is the second ever record of the species after its description. Therefore a short morphological comparison with the allotype specimen (deposited at The Natural History Museum, London) is provided below for this species only. It highlights morphological features that appear different on the newly collected female compared to the allotype.

Figure 5. Female vulvar lamina of *Hemicordulia cupricolor*.

Fraser (1927) does not describe the female synthorax in details. He found it "… a beautiful uniform golden-green or coppery metallic, quite unmarked with paler or darker areas." The new female does not have uniformly coloured synthorax. Light yellow and shiny green areas are traceable, but its exact position and degree of occupation cannot be described with certainty. The only specimen in the new collection has both sides of the synthorax marked differently for the reason being the state of preservation. An apparent purple-violet iridescent on the mesepisternum is the only addition that could be made to Fraser's original description. It is well developed on both sides of dorsal carina and becomes obscure towards the humeral suture. Metallic sheen over the rest of synthorax is mostly bright greenish. It darkens on anterior sides of both mes- and metepimeron and is unnoticeable on mes- and metinfraepisternum. Those features, however, should be explored further over a larger sample size before accepted as diagnostic. It is unclear if the thoracic markings on the single female are typical of the species or are due to the preservation method.

The latter could be the reason for some variations observed in the colouration of the abdomen compared to the original species description. Fraser (1927) claims that the allotype female lacks yellow markings on S3 in comparison to the holotype male. The female reported here, however, looks like having well developed yellow on the ventral abdominal area. It runs for almost the entire length saved for the last three segments, which appear light brownish. The dark abdominal pigmentation is broken at various places thus forming asymmetrical lighter patches on both lateral sides. It is unclear which of those are due to vanished colouration and which to a real pigmentation.

Nodal index of the new female (9-10/10-9; 11-6/6-9) differs from the one given for the allotype (7-9/8-6; 10-6/6-10). Fraser (1927) also reported of variations in the nodal indices of two specimens collected from Savai'i Island which also had larger bodies.

Figure 5 featuring the female vulvar lamina is provided here as the only significant supplement to Fraser (1927)'s description. Its shape is rather specific and may add to the correct identification of specimens collected in near future.

4. *Hemicordulia hilaris* Lieftinck, 1975
   Localities: 14 (1♂, 1♀); 19 (1♂)

LIBELLULIDAE

5. *Diplacodes bipunctata* (Brauer, 1865)
   Localities: 3 (1♂); 6 (3♀♀); 7 (1♀); 8 (1♂, 3♀♀); 17 (1♀); 20 (1♀)

6. *Lathrecista asiatica asiatica* (Fabricius, 1798)
   Locality: 6 (2♂♂)

7. *Pantala flavescens* (Fabricius, 1798)
   Localities: 2 (1♂, 1♀); 11 (1♂); 15 (1♀); 19 (1♀)

8. *Rhyothemis regia chalcoptilon* (Brauer, 1867)
   Localities: 3 (1♂, 23 March); 5 (1♂); 9 (1♂); 16 (1♀); 18 (1♀);

9. *Tholymis tillarga* (Fabricius, 1798)
   Localities: 2 (2♂♂); 3 (1♂, 23 March)

10. *Tramea transmarina* Brauer, 1867
    Localities: 1 (1♀); 10 (1♂)
    The female specimen has only the basal three abdominal segments and its final identification is arbitrary. It was identified as *T. transmarina* based on the thoracic pattern only which resembles the male of that species. However, the dorsal area of the frons differs from the typical male *transmarina*. The dark purple metallic on the top occupies less area and does not reach the anterior ridge of the frontal dorsum (Fig. 6a). The dark basal area of the hind wings also differs considerably in being so reduced to nearly absent in the new female (Fig. 6b).

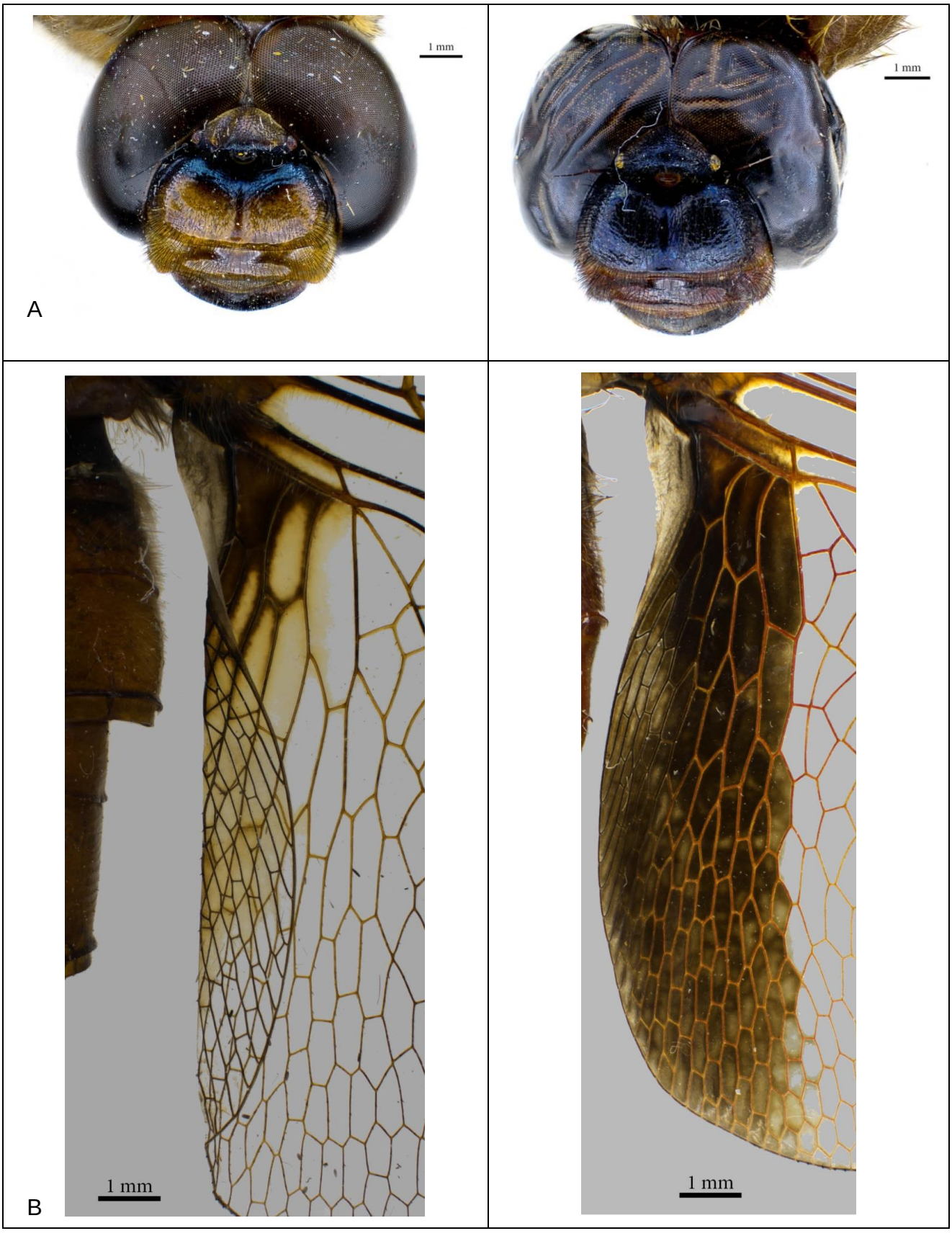

Figure 6. Comparison between the two specimens (female and male) reported in this paper as *Tramea transmarina*: a) occupations of the metallic area on the dorsal area of the frons, and b) extend of occupation of the dark basal area of hind wings. (left column: female; right column: male)

Discussion

The small Odonata collection from Samoan Archipelago presented here makes a small contribution to the taxonomy and fauna of the group. The rediscovery of *Hemicordulia cupricolor* is perhaps the most important finding. The species has not been confirmed for the area for nearly 90 years after Fraser's 1927 original description. That was one of the reasons for Marinov (2012c) not including *H. cupricolor* in the most recent representation of the world distribution of genus *Hemicordulia*. Question marks spanning the area between Samoan Archipelago and Society Islands were preferred instead due to some taxonomic and faunistic uncertainties associated with older records from the region. Marinov (2012c) followed Donnelly (1986) who reported on two congeneric species only for Samoan Archipelago: *H. hilaris* (known also from New Caledonia to Cook Islands) and *H. pacifica* (Upolu and Tutuila Islands).

The present paper confirms *H. cupricolor* to Savai'i which is the second locality for the taxon apart from Upolu (the type locality). Apart from *H. cupricolor* all other species reported here are either very widely distributed within the Pacific or recorded in almost every other previous paper from the region. Two of them *Tramea transmarina* (one male, Hala Tahi Hikutavake coastal pool, 21 January 2013 and one male, Namukulu cottages, 21-24 January 2013) and *Pantala flavescens* (one male, Liku, 19-20 January 2013) have been recently collected from Niue (B. & A. Patrick leg.) about 600 km S-SE of Samoan Archipelago. Both of them have never been recorded from Niue, an island which is very depauperate of surface freshwater. *Diplacodes bipunctata* is the only other Odonata species previously known from Niue (Rowe 1987).

Encouragement of further systematic sampling is another important focus of this paper. The species checklist for the country is impressive. Thirty species (with nearly half of them endemic) is a remarkable number for such a small island archipelago where the largest longitudinal distances are measured at just about 60-70 km for Savai'i and Upolu and less than 30 km for Tutuila. The width of the same islands varies between about 45 km, 20 km and less than 10 km respectively. The present collection adds to the fauna of all three islands and provides the first record for Aunu'u Island – an island situated just off the SE shore of Tutuila Island. More records are provided in the literature from Tutuila Island than Savai'i although the second is less inhabited and seems to provide more biotopes for odonates. However, Donnelly (1986) argues that geologically young islands like Savai'i tend to have very limited surface water which in addition to the logistical problems that one might face accessing the high altitude sites of the island may explain the low number of records. The rugged terrain and lack of well maintained walking path should not discourage further research on the island.

Indeed, several bodies of standing water were noted in the dense forests during BIORAP helicopter flights (W. Chinn pers. obs.). Some of the upland water features were temporary ponds following intense rainfall filling the cinder-cone craters while others appeared to be more permanent in nature. Though standing and running water

is much reduced by the extreme porosity of the basalt and scoria basement geology and lack of catchment evolution on the shield volcano surface, there are a few higher altitude channels and crater swamps. These rare upland systems do not appear to have been sampled in Savai'i.

Figure 7. Night observation of *Hemicordulia cupricolor*-like individual.

H. cupricolor is a good example of how important the heart of the island is. The single female collected during the field work should not be regarded as an accidental species because another female that might be the same species has been collected, photographed (Fig. 7) and released at the site (Mata o le Afi, 1640 m a.s.l.). It was sampled during the night. Corduliids are predominantly day-flying insects and are largely underrepresented (compared to other Odonata families) in the light traps or other collection methods carried out during the night. In the most recent review of Odonata attracted by light Umar et al. (2012) noted Corduliidae being just 2% of all Odonata ever reported as coming to light sources. Although thorough and with a great attention to detail, this analysis may have missed some old data such as *H. cupricolor*. Fraser (1927) reported on one female that came to light. The present paper reports on night collection too, however, those were not actively flying individuals as they were easily hand picked up from the scrub vegetation. Our data should be considered with

caution in future Odonata sampling since late day activity is not typical of other members of the family and the genus. *Hemicordulia gracillima* Fraser, 1944 is the closest relative collected from near light as in fact the holotype female was established on this way (Fraser 1944).

Odonata records from Savai'i are interesting in another aspect. Only two out of 12 previously established species are endemic to Samoan Archipelago. All of them are predominantly pond-dwelling specialists, although species like *Agriocnemis exsudans* and *Ischnura aurora* (Brauer, 1865) survive near still sections of larger streams at sites where water forms bays – such as widening in the shore grass vegetation (M. Marinov, pers. obs.). In contrast the Odonata fauna of Upolu and Tutuila islands consists of 48% and 67% endemic species respectively with some of them, like *Amorphostigma armstrongi* Fraser, 1925 widespread in a variety of stream habitats (Donnelly 1986). This phenomenon of low endemism on Savai'i Island could be explained by environmental conditions, including geological age and origin of the islands Donnelly (1986). It seems logical to add the fact that in all occasions where data are reported with their locality they came from the periphery of the island and very close to the ocean. It is a widespread phenomenon that in the Pacific Odonata species like to stay near the ocean shore and forage on flying insects, a behaviour specifically recorded for the Kingdom of Tonga (Marinov 2012a, 2013). That is why more systematic samples from the inland areas of Savai'i may increase the number of endemic species to the island adding species new to science and solving important taxonomic issues. Two study cases (*Anaciaeschna jaspidea* and *Tramea transmarina*) are suggested below for further exploration.

The dark forehead of the male *A. jaspidea* reported here is an example of such an important taxonomic topic. Lieftinck (1949) described *Anaciaeschna melanostoma* sp. n. and illustrated the appendages of the single immature holotype male collected from Guadalcanal Island, Solomon Islands. He proposed that colour pattern (dark front of head, dorsal incomplete antehumeral spots, reduced breadth of mes- and metepimeral bands, wings deeply stained with golden yellow, and reduced light spots on the abdominal segments) rather than structural characteristics can be used for separating *melanostoma* from its closely allied *jaspidea*. In a recently completed study on the same island Marinov & Pikacha (2013) reported on an immature female which had the whole forehead diffused yellow which was not as bright as in whatever supposed to be typical of *jaspidea* nor was it as dark as what described for *melanostoma*. The final identification was obscured and authors left this topic open for exploring three hypotheses one of which related to the taxonomic validity of *melanostoma*. The here presented male specimen from Samoa shows no significant structural differences from *jaspidea* and possesses dark red area on the forehead in a similar way described for *melanostoma* differing in the extend of occupation. Lieftinck (1949) described the dark region in *melanostoma* as expanding over from the labrum up through to the clypeus and frons while in the Samoan specimen it descends from the top of the

frons and diffuses on the surface of postclypeus. The latter specimen also has traces of yellow antehumeral stripes (one of the diagnostic features for *melanostoma*) and anal appendages identical to what Lieftinck (1949) illustrated for *melanostoma* (Fig. 4). All those facts are in support of Marinov & Pikacha (2013) view of a necessity of a new revision of the taxonomic status of *melanostoma* in comparison with *jaspidea* from the rest of the Pacific.

The female identified here as *Tramea transmarina* is another interesting example. The original species description from Brauer (1867a) was based on a female collected from Viti Levu Island, Fiji. He noted the metallic area on the dorsal part of the head, but did not explain the extent to which it developed on the original specimen. With the lack of female specimens for comparison from other Pacific nations it is unclear as to what could be attributed the here reported dissimilarity illustrated on Figure 6a – sex related difference or the new female belongs to species other than *transmarina*. So far *T. transmarina* is the sole representative of the genus in the Samoan Archipelago (see Table I).

In his studies on Samoan Odonata Donnelly (1986) raised an important and to some degree worrying issue. Although he investigated the islands during the same time of the year and at the same places where the previous major collection efforts were being performed, only a few of Fraser's species from the "*Ischnura* complex" were discovered. This complex, consisting of Samoan endemic species, was found to be problematic in terms of its correct taxonomic position and relationships to other genera, like *Pacificagrion* and *Amorphostigma*. Donnelly (1986) concluded that Samoan *Ischnura* should not be kept within this genus, but due to insufficient sample size gave no further suggestions. Not finding species in their original localities is quite unfortunate since new material is needed in order to propose a plausible taxonomic position of these taxa. Donnelly (1986) did not consider habitat degradation as a possible explanation of the lack of new data, but commented on the possible negative impact of the introduced freshwater crayfish from French Polynesia. This is another fact in support of the suggested above systematic sampling over the course of a whole year.

The status of *Anax* species on Samoan Archipelago is another interesting discussion point in Donnelly (1986) and the last that is emphasised here. He noted the altitudinal separation of the two species recorded for the region – *A. guttatus* (Burmeister, 1839) abundant at lagoons at low elevation (similar to what reported here for the species) and *A. gibbosulus* Rambur, 1842 thriving at about 730 m a.s.l. He attributed the observed morphological differences between the two closely related species to the specific thermal regime of the higher altitudes of the tropics with *gibbosulus* being larger, darker with restricted pale spots and having heavier anal appendages. Donnelly (1986) concluded that *gibossulus* might have derived from *guttatus* after it found ways to adapt to higher and harsher environment of the tropical islands. Further studies on the differentiation of habitat and ecology associated with altitude may

signal drivers for speciation and allopatry. Supporting evidence for such hypotheses would be observations of similar sister species relations elsewhere in the Pacific.

Acknowledgements

The authors wish to thank staff at SPREP and CI (Conservation International - Apia) and their contractors - in particular Bruce Jefferies and James Atherton for their initiation of the 2012 BIORAP. Thanks Czarina Iese, Tone Simanu and Joe Pesi MNRE Ministry of Natural Resources and Tavita Togia American Samoa National Park. Thanks Lainey Berry, Stephen Turnbull DMWR Department of Marine and Wildlife Resources. We are also grateful to New Zealand Department of Conservation for support in Samoa and the New Zealand Airforce for helicopter logistics while on Savai'i. Alex, Hamish and Tesca Edwards assisted with collections. Both Stephen Brooks and Benjamin Price, The Natural History Museum, London assisted us with high quality images contributing important information for the taxonomic discussion presented here. Figures 3-6 for the paper were produced using the laboratory equipment of Plant Health and Environment Laboratory, Christchurch, Ministry for Primary Industries, New Zealand.

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Apendix

Table I. Chronological literature review of Odonata records from Samoan Archipelago.

Chronological literature review of the Odonata species check-list of Samoan Archipelago					
No	**Verbatim species**	**Valid species name**	**Verbatim locality**	**Page**	**References**
1	*Tramea samoensis*	*Tramea transmarina* Brauer, 1867	Die Samoa oder Schifferinseln	22	Brauer (1867a)
2	*Celithemis Chalcoptilon*	*Rhyothemis regia chalcoptilon* (Brauer, 1867)*	die Samoa oder Schifferinseln	25	Brauer (1867a)
3	*Zyxomma tillarga*	*Tholymis tillarga* (Fabricius, 1798)	Samoa- oder Schiffer-Inseln	505	Brauer (1867b)
4	*Diplax bipunctata*	*Diplacodes bipunctata* (Brauer, 1865)	Upolu 1. Samoa-Ins.	505	Brauer (1867b)
5	*Agrion aurora*	*Ischnura aurora* (Brauer, 1865)	Upolu 1. Samoa-Ins.	505	Brauer (1867b)
6	*Pericnemis annulata*	*Melanesobasis annulata* (Brauer, 1869)*	Samoa-Ins.	10	Brauer (1869)
7	*Pantala flavescens*	*Pantala flavescens* (Fabricius, 1798)	Samoa	917	Ris (1909-1919)
8	*Macrodiplax cora*	*Macrodiplax cora* (Kaup in Brauer, 1867)	Samoa	1036	Ris (1909-1919)
9	*Pseudagrion samoensis*, sp. nov.	*Pseudagrion samoense* Fraser, 1925*	Sumiu, Upolu	430	Fraser (1925)
10	*Agriocnemis exsudans* Selys.	*Agriocnemis exsudans* Selys, 1877	Apia	432	Fraser (1925)
11	*Amorphostigma armstrongi* sp. nov.	*Amorphostigma armstrongi* Fraser, 1925*	Apia	433	Fraser (1925)
12	*Hemicordulia pacifica* sp. nov.	*Hemicordulia pacifica* Fraser, 1925*	Apia	435	Fraser (1925)
13	*Hemicordulia oceanica* Selys.	*Hemicordulia hilaris* Lieftinck, 1975	Apia	436	Fraser (1925)
14	*Lathrecista asiatica asiatica* (Fabr.)	*Lathrecista asiatica asiatica* (Fabricius, 1798)	Vailele Marsh, Apia	436	Fraser (1925)
15	*Pacificagrion lachrymosa* sp. nov.	*Pacificagrion lachrymosa* Fraser, 1926*	Mololelei, Upolu	505-507	Fraser (1926)
16	*Agriocnemis interrupta*, sp. nov.	*Agriocnemis interrupta* Fraser, 1927*	Mololelei, Upolu	22	Fraser (1927)
17	*Ischnura buxtoni*, sp. nov.	*Ischnura buxtoni* Fraser, 1927*	Mololelei, Upolu Isl.	23	Fraser (1927)
18	*Ischnura haemastigma*, sp. nov.	*Ischnura haemastigma* Fraser, 1927*	Mololelei, Upolu Isl.	26	Fraser (1927)
19	*Ischnura albistigma*, sp. nov.	*Ischnura albistigma* Fraser, 1927*	Mololelei, Upolu Isl.	27	Fraser (1927)
20	*Ischnura chromostigma*, sp. nov.	*Ischnura chromostigma* Fraser, 1927*	Pago Pago, Afone Trail, Tutuila Island	28	Fraser (1927)
21	*Amorphostigma auricolor*, sp. nov.	*Amorphostigma auricolor* Fraser, 1927*	Mololelei, Upolu	30	Fraser (1927)
22	*Anax gibbosulus* Ramb.	*Anax gibbosulus* Rambur, 1842	Lanuto'o Lake, Upolu Isl.	34	Fraser (1927)

Chronological literature review of the Odonata species check-list of Samoan Archipelago					
23	*Anaciaeschna jaspidea* Burm.	*Anaciaeschna jaspidea* (Burmeister, 1839)	Lotofaga, Upolu	34	Fraser (1927)
24	*Gynacantha apiaensis*, sp. nov.	*Gynacantha apiaensis* Fraser, 1927*	Apia	35	Fraser (1927)
25	*Hemicordulia cupricolor*, sp. nov.	*Hemicordulia cupricolor* Fraser, 1927*	Malolelei, Upolu Isl.	37	Fraser (1927)
26	*Orthetrum sabina* Drury.	*Orthetrum serapia* Watson, 1984	Apia	42	Fraser (1927)
27	*Pacificagrion dolorosa* sp. n.	*Pacificagrion dolorosa* Fraser, 1953*	Apia	119	Fraser (1953)
28	*Ischnura sanguinostigma* sp. n.	*Ischnura sanguinostigma* Fraser, 1953*	Apia	123	Fraser (1953)
29	*Anax guttatus* Burm.	*Anax guttatus* (Burmeister, 1839)	Lanoto'o Lake, Upolo	111	Donnelly (1986)
30	*Diplacodes trivialis* (Rambur, 1842)	*Diplacodes trivialis* (Rambur, 1842)	Samoa	94	Dommanget & Mashaal (2000)

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