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The Odonata of Fais Island and Ulithi and Woleai Atolls, Yap State, Western Caroline Islands, Federated States of Micronesia

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Abstract—Fifty one adults of nine species of Odonata were collected by the author on Ulithi Atoll, Fais Island, and Woleai Atoll, Micronesia, between December 2007 and December 2009. Together with a previously unreported species from the 2001 Kagoshima University Expedition to Yap and Ulithi, they include 13 first island records and three easternmost records for the Caroline Islands. Breeding on one or more of the islands is confirmed for seven species. Five of the nine species (*Anax guttatus* (Burmeister), *Diplacodes bipunctata* (Brauer), *Pantala flavescens* (Fabricius), *Tholymis tillarga* (Fabricius), and *Tramea transmarina* Brauer) are widespread throughout Micronesia and are the species most likely to be encountered on the smallest and most remote islands, often with very limited available water.

Introduction

The Odonata of greater Micronesia, including the Mariana Islands, Palau, the Federated States of Micronesia (FSM), the Marshall Islands, and Kiribati (formerly the Gilbert Islands), were last reviewed by Lieftinck (1962). The status of species on some of the islands in the FSM has recently been updated (Buden & Paulson 2007, Buden 2010), but the odonate faunas of many of the small, remote, and far-flung islands remain unknown or represented by few records. Odonates have been recorded on only five of the 15 island groups comprising the outer islands of Yap State (Buden & Paulson 2007). The present study adds six species recorded for Fais Island, five for Woleai Atoll, and two for Ulithi Atoll.

Study Area

Yap, including the high islands of Yap proper and many widely scattered atolls and low, coralline islands, is one of four states (with Chuuk, Pohnpei, and Kosrae) that comprise the island nation of the Federated States of Micronesia. The FSM and Republic of Palau make up the Caroline Islands chain, which spans approximately 3,000 km of the west-central Pacific Ocean between the Philippines and Indonesia to the west and the Marshall Islands to the east (Fig. 1). Fais (9° 46' N, 140° 31' E)

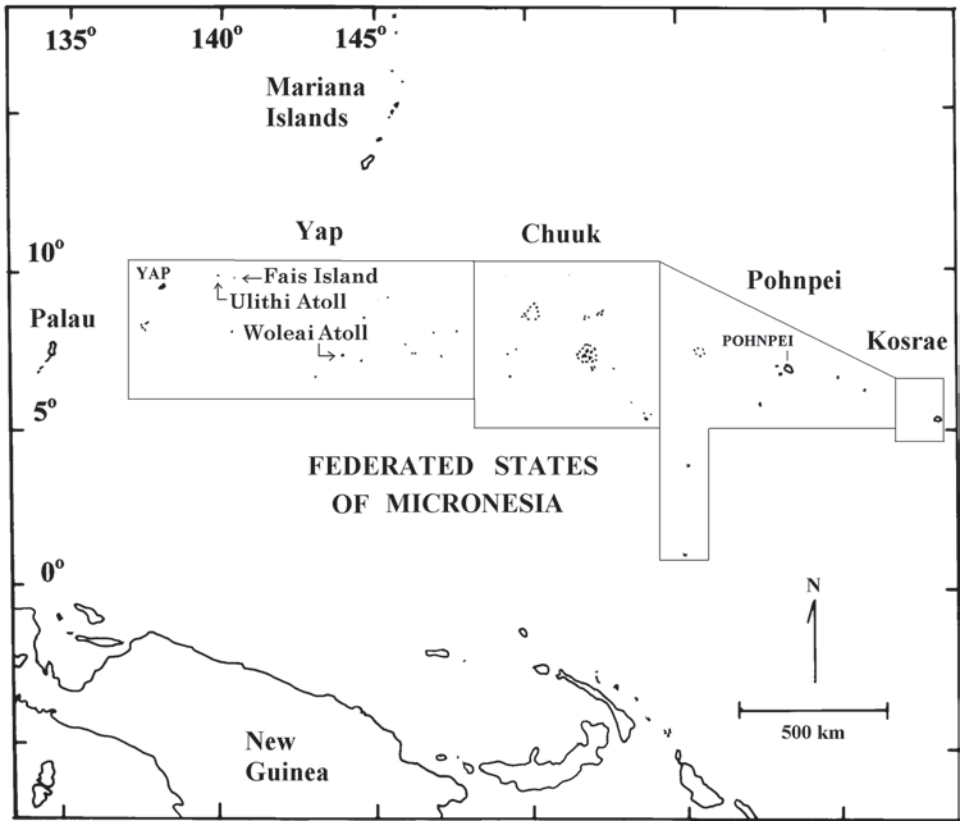

Figure 1: Location of Yap State, Federated States of Micronesia, and surrounding islands.

is a small (2.7 km long, 1.1 km wide, 2.8 km^2), low (28 m) raised coral island that was extensively mined for phosphate in the late 1930s and early 1940s during the Japanese administration (Intoh & Yamaguchi 1996). It is located approximately 220 km east of Yap proper and 80 km east of Ulithi Atoll, the nearest land. The interior of the island is a mosaic of grassy areas with patches of scrubby woodlands, and small garden plots. Approximately 300 residents inhabit a settlement at the southeastern part of the island. Ulithi and Woleai are classic atolls that include several to many small, low, (ca 3–5 m elevation), predominately coconut-forest clad islands distributed along a barrier reef enclosing a lagoon. Ulithi, 160 km northeast of Yap, has 49 islands with a total land area of 4.66 km^2. The largest island on Ulithi Atoll is Falalop (0.94 km^2). Woleai, 617 km west of Yap, has 22 islands with a total land area of 4.53 km^2. The largest island on Woleai Atoll also is named Falalop; it is 1.53 km^2.

Aquatic habitats on these islands consist largely of man-made catchments and wells, rain-filled bomb craters from WWII, and pits excavated for cultivation of taro, or produced incidentally during various construction projects. Fais

is especially xeric and the resident islanders frequently cultivate swamp taro, *Cyrtosperma merkusii* (= *chamissonis*), and other aroids in cement tanks. The largest taro tanks are about 15 x 10 m, with walls usually less than one meter high, and often contain varying amounts of algae-laden water. An open well on the west side of the island, hand-dug by local residents sometime in the past, is the only place where the water table is exposed to the surface (MacCracken et al. 2007). Falalop Island, Woleai, has patches of marshy, swampy areas, and a small shallow pond at the west end of the runway, but these likely go dry during extended periods of drought.

Methods

Odonata were surveyed on Fais Island from 17 to 21 December 2007 and 23 to 29 June 2009, on Falalop Island, Woleai Atoll on18 June 2009, and Falalop Island, Ulithi Atoll from 18 to 21 December 2009. A total of 51 adults were hand netted, dried in envelopes and are currently stored at the College of Micronesia pending transfer to curated collections elsewhere. Odonatological results of the 2001 Kagoshima University Expedition to Yap and Ulithi, most of which have been summarized by Buden & Paulson (2007), are also reported here and include one previously unpublished record. Place names and land area measurements are from Bryan (1971). The atolls are occasionally referred to as if they were single islands, but with the understanding that each includes several to many small islets. Terms of abundance are based on encounter rates during this survey unless indicated otherwise i.e., very common—seen daily in large numbers, often several hundred to over 1,000 per day, common—at least 25 encounters on most days, uncommon—usually no more than 10 sightings per day and unobserved on some days, scarce—usually no more than five encounters in a single day and not encountered on most days.

Species Accounts

Zygoptera
Coenagrionidae
Agriocnemis femina (Brauer)

This species is widely distributed from Asia to Australia, but has been recorded in Micronesia only from the southern Mariana Islands, Palau and Yap (Lieftinck 1962). Buden & Paulson (2007) found it locally common in Yap, mainly in grassy, weedy areas adjacent to forest streams. Three specimens collected on Mogmog Island by the Kagoshima University Expedition on 25 October 2001 (K. Tsuda in litt.) are the first for Ulithi Atoll, and the easternmost records for the Caroline Islands. Whether these represent a breeding population is unknown, but forest streamside habitats, where this species is usually encountered on Yap proper, do not occur on the atolls.

Anisoptera
Aeshnidae
Anaciaeschna jaspidea (Burmeister)

This species was scarce to uncommon on Fais in December 2007, where it was usually seen in the vicinity of the taro tanks. One female was collected as it was ovipositing in rotting vegetation along the edge of the well in disturbed woodland. These are the first records of *A. jaspidea* for Fais, and the easternmost records in the Caroline Islands. None was seen during the June 2009 visit.

Anax guttatus (Burmeister)

This species was scarce to uncommon on Fais in June 2009, being encountered occasionally, and mainly in the vicinity of taro tanks; one was observed ovipositing in dead vegetation at the edge of the well on 24 June, and one exuvia was taken from an emergent plant growing out of a taro tank (Table 1) . It was more numerous on Woleai, where I saw five or six on patrol over a small pond at the end of the runway, and two or three others along a trail through scrubby woodland, all on 18 June 2009. There are no documented records for Ulithi, but a large, bluish green dragonfly that local residents say occurs at times is almost certainly this species.

Table 1: Breeding records[a] of Odonata on Fais Island and Woleai Atoll in December 2007 and June 2009

	December	June	
Species	Fais	Fais	Woleai
Anaciaeshna jaspidea	O^{1}		
Anax guttatus		O^{1}, E^{1}	
Diplacodes bipunctata	T^{1}, O^{2}		
Neurothemis terminata	$T^{1\text{-}5}$, $C^{1\text{-}5}$, $O^{>10}$	$C^{>10}$,$T^{1\text{-}5}$,$O^{>10}$	
Rhyothemis phyllis			C^{1}, O^{1}
Tholymis tillarga		O^{1}	
Tramea transmarina	$C^{1\text{-}5}$, $T^{1\text{-}5}$	$T^{1\text{-}5}$, OT^{1}, E^{33}	T^{1}

[a] C = mating pair in copula, E = exuviae [indicate breeding but not specific time of emergence], O = ovipositing female, OT = ovipositing female in tandem with male, T = mating pair in tandem (not ovipositing). Superscript numbers refer to females ovipositing, mating pairs, or numbers of exuviae, as noted.

Libellulidae
Diplacodes bipunctata (Brauer)

This species was uncommon to locally common on Fais during the December 2007 and June 2009 visits, and usually encountered in sparsely vegetated areas in or near the settlement and at taro tanks, but it was the most abundant odonate on Woleai where I observed several hundred on 18 June 2009. Breeding probably

Table 2: Locality records[a] for Odonata on three Yap State Outer Islands, with distribution of 51 specimens collected between December 2007 and December 2009

Species	Ulithi	Fais	Woleai
Agriocnemis femina	K1*		
Anaciaeshna jaspidea		+(3♀)*	
Anax guttatus	?[b]	+(2♂)*	+(1♂)/A
Diplacodes bipunctata	+(1♀)/K2	+(1♀)*	+(2♀)*
Macrodiplax cora			+(5♂)*
Neurothemis terminata	+(2♂,2♀)/K2	+(3♂,4♀)/K2/L	
Pantala flavescens	K2	+(1♀)/L	
Rhyothemis phyllis	+(1♂)/K2	+(2♂)*	+(2♂)*
Tholymis tillarga	+(1♂)*	+(3♂,2♀)*	+(1♀)*
Tramea transmarina		+(6♂,5♀)*	+(1♂)*

[a] + = this study; * = first record; A = Asahina (1940); K1 = 2001 Kagoshima University Expedition, unpublished record (K. Tsuda in litt.); K2 = 2001 Kagoshima University Expedition record (in Buden and Paulson 2007); L = Lieftinck (1962).

[b] Description by local residents fits this species but identification needs confirmation—see species account.

occurs year-round (Table 1) wherever suitable habitat is present. The Kagoshima University Expedition collected three on Falalop Island and two on Mogmog Island, Ulithi Atoll, in October 2001 (K. Tsuda in litt.), and I saw only two on Falalop Island, Ulithi during 18-21 December 2009.

Macrodiplax cora (Brauer)

This predominately Southeast Asian and Indo-Australian species was very common on Woleai Atoll on 18 June 2009 with hundreds observed in the grassy, weedy verge of the airstrip. Five males were collected. The only other records for the FSM include a single male collected on Yap proper by R. J. Goss, July-August 1950 (Lieftinck 1962), and large numbers encountered on Houk Island (= Pulusuk Atoll), Chuuk State, in December 2002 (Buden & Paulson 2004). Other Micronesian records for this species include the Mariana Islands and Palau (Lieftinck 1962).

Neurothemis terminata Ris

Lieftinck (1962) recorded this predominately Southeast Asian species in Micronesia only in Palau and Yap, stating that "many" were collected at "various localities" in Yap proper. At least 28 were collected on Ulithi Atoll during the Kagoshima University Expedition in October 2001 (Buden & Paulson 2007), but I saw no more than 50 over a period of three days in December 2009. Krauss collected at least one specimen (now in the Bishop Museum) from Fais Island in October 1952 (Buden & Paulson 2007), and I found it to be the most abun-

dant odonate there during the December 2007 and June 2009 visits. It was most numerous in tall grass and shrubs alongside trails in disturbed woodland, and in the vicinity of taro tanks. I counted 70 in five min (= 840/hr) in ~ 100 m along a trail northwest of the settlement on 20 December, and encountered densities as great or nearly as great in similar habitats throughout the island. This figure is comparable to the encounter rate of 960/hr that I recorded on Yap proper in 2005, where it also was the most abundant odonate (Buden & Paulson 2007). Breeding takes place throughout the year, at least on Fais (Table 1). There are no records for Woleai Atoll. The only record in the FSM east of Fais is one specimen in the Bishop Museum labeled as collected on Kosrae in 1936 (Buden & Paulson 2007).

Pantala flavescens (Fabricius)

This nearly cosmopolitan species was observed in small numbers on Ulithi Atoll and Fais Island. Its occurrence on these and other small low-lying atoll islands of the FSM may be in part seasonal—see for example Buden (2010). I saw approximately 15 *P. flavescens* on Fais during 17–21 December 2007; Lieftinck's (1962) mention of the species being recorded on Fais by Krauss in October 1952 was inadvertently omitted by Buden & Paulson (2007). I saw none on Ulithi in December 2009, but the Kagoshima University Expedition collected one each on Falalop and Asor Islands in October 2001. The absence of records from Woleai is probably an artifact of sampling.

Rhyothemis phyllis (Sulzer)

This species has been recorded in Micronesia from Guam, Palau, and Yap (Lieftinck 1962). Buden & Paulson (2007) considered it uncommon to locally common on the main islands of Yap. It is apparently scarce on Ulithi, where the only records are one collected in October 2001 (Buden & Paulson 2007), and another on 20 December 2009 (this study). It is similarly scarce on Fais where the only records are two specimens I collected at taro tanks, one on 20 December 2007, and another on 27 June 2009. But it was common at Woleai Atoll on 18 June 2009. The approximately 100–150 *R. phyllis* that I observed at the airstrip pond (two collected) are first records for Woleai and the easternmost records for the Caroline islands. Breeding is confirmed (Table 1).

Tholymis tillarga (Fabricius)

This species is probably more numerous than the few records indicate, but it is most active and most frequently encountered during late afternoon and at dusk, whereas most surveys were conducted during midday. I observed approximately 15 *T. tillarga* on Fais during 17–21 December 2007, most of them being flushed from trailside vegetation in grassland and disturbed woodland, but I encountered it more frequently at water-filled taro tanks in June 2009. Breeding was confirmed (Table 1). The only records for Ulithi Atoll are the several I observed (one collected) after they flushed from trailside vegetation in disturbed woodland on 19 December, and two others I saw over open cisterns on 20 December 2009. The only record for Woleai is a specimen I collected at a water-filled pit on 18 June 2009.

Tramea transmarina Brauer

This species was common on Fais during both the December 2007 and the June 2009 visits, and usually encountered over water at the taro tanks, less frequently in open, grassy areas and agricultural lands. Thirty three exuviae were collected from emergent plants *(Ludwigea octovalvis)* at a single water-filled taro tank in June 2009, but the time of emergence is unknown; some showed deterioration, but most seemed fairly fresh. Breeding probably occurs year round (Table 1). Approximately 10–15 adults, including a pair in tandem, were observed (one collected) over a small pond at the west end of the runway at Woleai Atoll on 18 June 2009. There are no records of *T. transmarina* for Ulithi, but given its abundance on nearby Yap proper (Buden & Paulson 2007), and its widespread distribution among the islands of the FSM (Lieftinck 1962), its apparent absence on Ulithi probably is an artifact of sampling.

Discussion

The 10 species of odonates recorded from Fais Island and Ulithi and Woleai Atolls include one Zygoptera, *Agriocnemis femina,* and nine Anisoptera. The record of *A. femina* from Ulithi may represent a single fortuitous and short-lived occurrence as it was found once on one island where three specimens were collected. It is not known from any other atolls in the FSM, nor, with the exception of a single anomalous record from Pohnpei (see Buden & Paulson 2007), on any of the high islands east of Yap proper.

Five of the nine Anisoptera *(Anax guttatus, Diplacodes bipunctata, Pantala flavescens, Tholymis tillarga,* and *Tramea transmarina)* are widely distributed in the Pacific region, and in some cases well beyond. They form a core complex of species found on many small, remote, and nearly waterless islands throughout the FSM, and they breed opportunistically in meager and often ephemeral and anthropogenic sources of water (DWB, pers. obs.). Three species *(Anaciaeshna jaspidea, Neurothemis terminata,* and *Rhyothemis phyllis)* are not known to breed in the Caroline Islands east of the western half of Yap State, although there is one old, anomalous record of *N. terminata* from Kosrae (Buden & Paulson 2007). The distribution of the one remaining species, *Macrodiplax cora,* in Micronesia, however, remains especially sketchy and its status uncertain. Lieftinck (1962) recorded a male and two females from Saipan (Mariana Islands), two females from Palau, and a male from Yap proper. Buden & Paulson (2004) considered *M. cora* the most abundant odonate on Houk Island (Chuuk) in December 2002, and it was one of the most abundant odonates on Woleai Atoll in June 2009 in this study. Eleven atolls and isolated coral islands are located within the 585 km separating Woleai from Houk, but with the exception of a few records from Ifaluk, they are completely unknown odonatologically. There are no breeding records of *M. cora* in the FSM, but some of the females collected on Houk released numerous eggs during capture (Buden & Paulson 2004). This species is migratory (Lieftinck 1962), and to what extent the Micronesian populations include transients as well as residents is unknown.

The present study provides only a preliminary assessment of the Odonata of these islands. It is based, in the cases of Ulithi and Woleai, on only one or two brief visits to one or a few of the many islands that make up the atolls. Resident islanders claim that dragonflies are more common at certain times of the year than at others. One of the village chiefs on Ulithi stated that they usually show in greater numbers in late summer, following the west wind. A similar observation was made by the chief of Ngulu Atoll (see Buden 2010). Accurate assessments of the odonate faunas of these and other small, remote islands throughout the FSM require multiple visits over different times of the year, and over a period of several years, to account for seasonality as well as the effects of storms, protracted droughts, and other environmental perturbations whose impacts on the biota are likely to be magnified on these miniscule areas of land. Further comparisons of populations on the uninhabited atolls, where natural water resources are extremely limited, with those that have been anthropogenically modified and provide opportunistic habitats for odonates would also be instructive. The lack of reliable transportation to these remote outposts, however, continues to be an major obstacle to such studies.

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