

The Odonata of Pakin, Ant, Mokil, and Pingelap Atolls, Eastern Caroline Islands, Micronesia

DONALD W. BUDEN

*Division of Natural Sciences and Mathematics,
College of Micronesia-FSM, P. O. Box 159,
Kolonja, Pohnpei FM 96941
E-mail: don_buden@comfsm.fm*

Abstract—Seven species of Odonata are recorded from among Pakin, Ant, Mokil, and Pingelap atolls, Eastern Caroline Islands, Micronesia—one Zygoptera (damselfly), *Ischnura aurora*; and six Anisoptera (dragonflies), including *Anax guttatus*, *Agrionoptera sanguinolenta*, *Diplacodes bipunctata*, *Pantala flavescens*, *Tholymis tillarga*, and *Tramea transmarina*. None is endemic to the islands, but *A. sanguinolenta* is known to breed only in Chuuk and Pohnpei states, east-central Micronesia; the six others are widely distributed in Oceania and the Indo-Australian region, and in some cases well beyond. The largest number of species recorded on any one of the four atolls is five each on Mokil and Pingelap—six each if unconfirmed records of *A. guttatus* are accepted. Multiple surveys on Ant and Pingelap atolls reveal differences in species composition on the two atolls, but no marked seasonal variations. Evidence of breeding was obtained for all but the two least common species (*I. aurora* and *D. bipunctata*) and data suggest that breeding occurs year-round.

Introduction

Lieftinck (1962) reviewed the Odonata of Micronesia, including Palau, the Mariana Islands, the Marshall Islands, and the Federated States of Micronesia (FSM)—Yap, Chuuk (formerly Truk), Pohnpei, and Kosrae states. Populations have been reassessed on Pohnpei (Paulson 2003, Paulson and Buden 2003) and Kosrae (Buden and Paulson 2003), but odonate faunas elsewhere in the FSM have remained unstudied since Lieftinck's review. Information on atoll populations of Odonata is especially scanty. In his introduction to the "Insects of Micronesia" project, Gressitt (1954: 206) stated "atolls and low islands have not been adequately sampled, and a few have not been visited by entomologists...[and] the most neglected atolls are some near Ponape—like Pakin, Ant, and Ngatik [= Sapwuahfik]...." Reflecting this lack of information, Lieftinck's (1962) odonate records for Pakin, Ant, Mokil, and Pingelap atolls (all in Pohnpei State) consist only of an unstated number of *Ischnura aurora* from Pingelap and a male *Agrionoptera sanguinolenta* from Mokil collected by R. P.

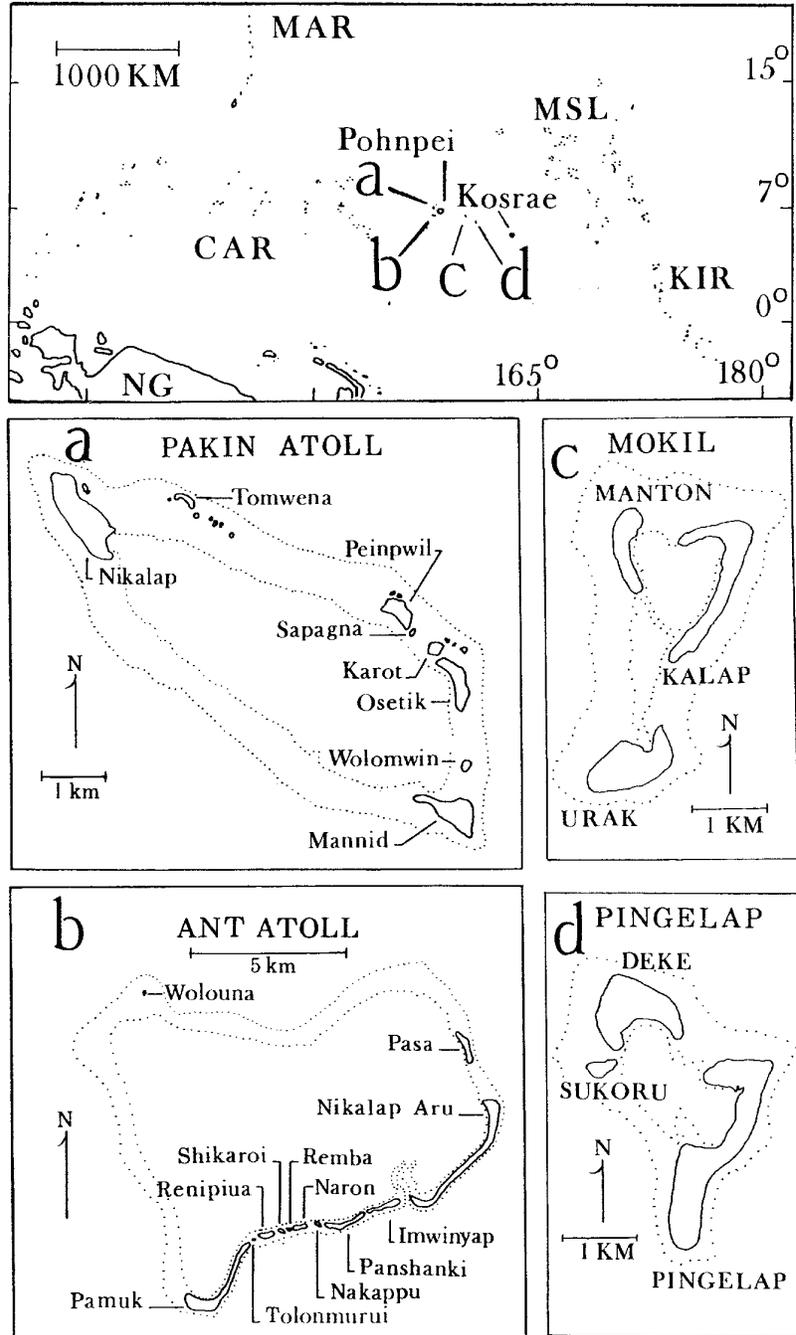


Figure 1: Locations of Pakin, Ant, Mokil, and Pingelap atolls; CAR = Caroline Islands, KIR = Kiribati, MAR = Mariana Islands, MSL = Marshall Islands, NG = New Guinea.

Owen in July 1949, and one *Pantala flavescens* collected on Pingelap by J. L. Gressitt in January 1953. No other records are known.

This study presents additional information on the distribution and relative abundance of Odonata on these tiny, remote, tropical Pacific islands based largely on my collections and observations made intermittently in 2002.

Study Area

Pakin, Ant, Mokil, and Pingelap atolls of Pohnpei State and the Federated States of Micronesia span about 320 km from west to east approximately 6°-7° north of the equator in the Eastern Caroline Islands in the west-central Pacific Ocean (Fig.1). The number of islands on each atoll ranges from three on Mokil and Pingelap to 12 on Ant and approximately 21 on Pakin, depending on how the smallest islets are considered; some may have dry-land connections during the lowest tides. The total land area is minuscule and nearly the same on each atoll, ranging from 1.1 km² on Pakin to 1.9 km² on Ant; Pingelap Island (1.1 km²) is the largest island. The highest elevations on these low-lying, coralline islets are usually no more than 3-4 m asl, although Weckler (1949) estimated the east side of the taro pit on Kalap Island, Mokil Atoll to be about "25-30 feet" (8-9 m). Pohnpei is the nearest high island, with distances to Pakin, Ant, Mokil, and Pingelap being approximately 33, 15, 174, and 289 km, respectively. All the islands fall within the equatorial rain belt and support a mesophytic vegetation (Mueller-Dombois and Fosberg 1998).

Coconut (*Cocos nucifera*) forest (= atoll forest) is the predominant vegetation on all but the smallest islands, where coastal scrub and strand predominate. The understory and groundcover of young coconut trees, hardwood saplings, shrubs, and ferns vary in density according to the extent and recency of clearing by islanders who harvest coconuts, crabs, and other island commodities. The forest abuts the beach or merges with a narrow, discontinuous band of coastal scrub and thicket dominated by *Scaevola taccada* and *Tournefortia argentea*. Shrubby patches of *Pemphis acidula* are scattered along the shore as are grasses, sedges, and numerous vines including *Ipomoea pes-caprae*, *Vigna marina*, and *Canavalia* sp. Large examples of *Barringtonia asiatica*, *Calophyllum inophyllum*, *Cordia subcordata*, and *Hernandia nymphaeifolia* trees occur on the sheltered (lagoon) sides of many islands, their boles being 1-3 m diameter at breast height, although with crowns only 10-15 m high. Mangroves are scarce or absent.

The limestone soils tend to be sandy on the lagoon side and rocky on the ocean side; broken pieces of coral often form ramparts on the windward shore and are scattered through much of the interior. Subterranean fresh water lenses occur on the larger islands but naturally occurring permanent bodies of fresh water are lacking. Taro pits on Mokil and Pingelap atolls (3.24 and 10.12 ha, respectively [Damas 1994]), retain water for much of the year and form an artificial wetland. Small depressions in the land throughout the islands hold transient pools of rain-water, with some apparently reaching the freshwater lens and holding water for

longer periods. These forest pools are usually only 1-2 m across and less than 0.5 m deep and, at least on Pakin and Ant, used as wallows by free-ranging and semi-feral pigs. Wells and cisterns, some with lids or roof-like covers and others completely uncovered, occur close to areas of current and former habitation.

Damas (1994: 50) reported the average annual rainfall for Pingelap as “about 156 inches” [396 cm] during October 1969-March 1974, with data for 15 months missing; the average for 1994-2001 (with January 1999 data missing) was 410 cm, with monthly averages ranging from 29 cm in June and November to 41 cm in December (National Weather Service Office, Kolonia, Pohnpei, unpublished data). The average for the 12 months October 1998-September 1999, which included an El Niño induced drought, was 228 cm. Soucie (1983) recorded an average of “50.12 inches” annually on Mokil during 1941-1970, but this figure seems too low in view of the figures for adjacent Pingelap. Possibly the original figure was approximately 129 inches but mistakenly treated as centimeters and unnecessarily and erroneously converted. If so, the average for Mokil would be approximately 328 cm for this time period and comparable to Pingelap records. Rainfall data for Ant and Pakin, and more recent records for Mokil, are unavailable.

Methods

Terms of relative abundance are based on impressions from observations throughout the study period: very common (50 or more encounters per day on most days under suitable viewing conditions and in suitable habitat), common (25-50 encounters per day on most days) fairly common (10-25 encounters on most days), uncommon (1-9 encounters per day, including unrecorded on many days). Oviparous females are those with eggs being extruded from the abdomen when captured or while being processed shortly after capture. Rainfall data, island area, and distances were converted to metric units if reported otherwise in the original source. Island names are from Bryan (1971) and various maps. The location map (Fig. 1) is a composite of maps from Buden (1995, 1996a, 1996b). The atolls were visited 29 March-1 April (Pingelap), 10-11 May (Ant), 29 July-2 August (Mokil), 7-9 August (Pakin), 7-8 September (Ant), 6-9 November (Ant), and 13-16 December (Pingelap), all in 2002. Ancillary information was obtained during bird surveys on Ant Atoll, 28-31 March and 16-18 November 2001. Unless stated otherwise, specimen records and field observations are the author's from surveys on the main island of each atoll: Nikalap on Pakin Atoll, Nikalap Aru on Ant, Kalap on Mokil, and Pingelap Island on Pingelap Atoll. Additionally, at least three hours each were spent on Manton and Urak islands, Mokil Atoll, and Deke, Pingelap Atoll, and about one hour on Sokoru, Pingelap Atoll. All islands on Ant Atoll were crossed along their long, central axes, and most were traversed also along shore routes, either on lagoon or ocean sides, or both. Nearly a full day was spent on Osetik Island, Pakin Atoll with a brief (ca. one hour) visit to Peinpweil, but strong winds persisted for much of the day dampening odonate activity.

Species Accounts

Zygoptera

Coenagrionidae

Ischnura aurora (Brauer)

Owen (in Lieftinck 1962) recorded *I. aurora* on Pingelap in July 1949. During the present study, this species was observed only in the dense vegetation (taro, grasses and sedges) in the community taro patch on Pingelap on 31 March. Only four were seen during a 45min survey of the area, and very few at other times during this visit. None was encountered during the 13–16 December visit, but the interior of the taro patch was not examined then, and the peripheral areas only briefly so.

Anisoptera

Aeshnidae

Anax guttatus (Burmeister)

Fairly common in the vicinity of the disbanded resort construction at Ant Atoll on 10 and 11 May, somewhat less numerous during September and November; uncommon elsewhere. Five to ten *A. guttatus* were observed in the main settlement on Pakin Atoll during 7–9 August, usually flying close to the ground just prior to daylight until about one hour after sunrise, after which sightings were scanty and irregular; three specimens collected were all females. No confirmed records exist for Mokil and Pingelap atolls, although unconfirmed reports by local residents of a very large dragonfly seen from time to time probably pertain to *A. guttatus*.

Breeding evidence is from a small, (5x7 m surface dimensions) water-filled pit at the disbanded construction site (and immediate vicinity) on Ant Atoll. A pair was observed *in copula* on 10 May and one or more females were ovipositing on several different occasions during 10–11 May and again on 6 November; oviposition sites included subsurface portions of emergent dead branches that had fallen into the pit, and the wet sides of the pit itself. Seventeen exuviae were collected on the emergent branches in the pit and at least one larva was seen in the water on 10 May; no exuviae were observed in September, and seven were found in November.

Libellulidae

Agrionoptera sanguinolenta (Lieftinck)

Encountered on three of the four atolls; unrecorded only on Pingelap. *Agrionoptera sanguinolenta* was the only odonate observed regularly (albeit in small numbers) at water holes, puddles, and pig wallows in well-shaded forest areas, but it was scarce or absent in the open areas or in settlements where other odonates were most frequently encountered. The specimens are typical of *A. s. sanguinolenta* and show no morphological approach to *A. s. pusilla* Lieftinck (1962) from Chuuk, the next island group to the west.

A pair was observed *in copula* among low shrubs and small trees at the edge of *Cocos* forest on Ant Atoll on 11 May. A female was collected ovipositing in a small (< 1m², 6-8 cm deep) puddle on the forest floor near this site on 7 September. Another female was reared from a larva collected just above the water-line on the side of a cistern on Pakin Atoll on 8 August (imago emerging 11 August), and two exuviae were collected from the same cistern on 7 August, one with the desiccated partial remains of a thorax from an apparently long-aborted emergence still attached. Five other exuviae were collected from one cistern in the settlement on Mokil on 29 July.

Diplacodes bipunctata (Brauer)

The least common of Anisoptera among the four atolls. One was seen on Pingelap on 29 March and three or four others during 13-16 December. Another was seen on Mokil during 29 July-2 August; there are no records for Pakin and Ant atolls.

Pantala flavescens (Fabricius)

The most frequently encountered and by far the most abundant dragonfly on Pingelap Atoll, where it comprised more than half the specimens collected during March/April (18 of 26 = 69%) and mid-December (15 of 28 = 53%). All 18 collected during March/April were males; specimens collected in December included 10 males and five females. This species was most numerous over the village roads, the community taro patch, and in an open grassy area adjacent to the airstrip, where 10-15 were seen flying in loose formation 2-4 m above the ground during late afternoons on several occasions during both visits. Although abundant in Pingelap Village, only one was encountered in the adjacent *Cocos* forest.

Several *P. flavescens* were observed daily on Mokil Atoll during late July and early August, usually in flight over the taro patch and the roads (lanes) in the village. Two to three were seen on Pakin during 7-9 August. The lack of any confirmed records from Ant Atoll is surprising in view of its close proximity to Pohnpei, where *P. flavescens* is common (Paulson and Buden 2003). One golden-colored dragonfly seen briefly in flight at the construction site on Nikalap Aru on 7 September may have been this species, but viewing conditions were inadequate for positive identification.

A pair was observed *in copula* on Pingelap on 29 March and an ovigerous female was collected there on 15 December. One exuvia was collected in a cistern in the settlement on Mokil on 31 July.

Tholymis tillarga (Fabricius)

Uncommon to locally fairly common on three of the four atolls, the apparent absence on Pakin possibly is a sampling bias due to the short duration of the visit and inclement weather for part of the time. It was most numerous in taro patches on Mokil and Pingelap atolls and in the vicinity of modular water tanks near resort construction on Ant Atoll. Most of the sightings were from late afternoon to sunset.

Table 1: Distribution of Odonata (M = males, F = females) collected on Pakin, Ant, Mokil, and Pingelap atolls during March–December 2002.

Species	Pakin	Ant	Mokil	Pingelap
<i>Ischnura aurora</i>	0	0	0	2M, 1F
<i>Anax guttatus</i>	3F	10M, 1F	? ^a	? ^a
<i>Agrionoptera sanguinolenta</i>	2M, 1F	8M, 3F	1M	0
<i>Diplacodes bipunctata</i>	0	0	1M	1M, 2F
<i>Pantala flavescens</i>	1M	? ^b	2M	28M, 5F
<i>Tholymis tillarga</i>	0	2M, 3F	5M	4M
<i>Tramea transmarina</i>	0	32M, 10F	7M, 2F	8M, 3F

^aUnconfirmed reports by local residents regarding occasional sightings of a very large dragonfly probably pertain to *A. guttatus*.

^bThe single sight record (see species account) requires confirmation.

One ovigerous female was collected on 10 May, one was ovipositing in a water tank on 11 May, and another in a water-filled pit on 7 September, all on Ant Atoll, and one exuvia was collected from a neglected cistern containing an accumulation of plant debris in *Cocos* forest on Manton I., Mokil on 31 May.

Tramea transmarina Brauer

Common on Ant and Mokil atolls and uncommon to fairly common on Pingelap; absence of records from Pakin Atoll possibly is an artifact of sampling. This species was usually encountered in open, grassy, weedy areas, and flying 2–5 m above the ground.

A pair was observed *in copula* on Pingelap Atoll on 29 March, and another on Ant Atoll on 10 May. Five pairs were observed in tandem on Mokil in July (1) and August (4), and at least seven others on Ant in September (3) and November (4); seven of the females were extruding eggs when collected. Two single ovigerous females were collected on Pingelap on 31 March and 14 December, and another on Ant on 10 May. One female was ovipositing in an open cistern on Mokil on 1 August and another in a water-filled pit at the construction site on Ant Atoll on 9 November. One exuvia was collected from a dead branch protruding above the water surface of the pit on 6 November.

Discussion

Seven species of Odonata are known from the four northeasternmost Pohnpei State atolls—Pakin, Ant, Mokil, and Pingelap (Table 1). All seven are common on Pohnpei, the nearest high island, and all except *Agrionoptera sanguinolenta* (see

below) are species widespread throughout the Pacific and in most cases well-beyond (Steinmann 1997). None of the atolls is known to have all seven species. Pakin has three, Ant four, and Mokil and Pingelap each have five, but additional surveys may augment some of these numbers. Fieldwork on Pakin, for example, was limited to only about one full day, and inclement conditions (strong winds) prevailed much of the time. Also, confirmation of *Anax guttatus* on Mokil and Pingelap atolls (see species account) would bring the total to six each. Limited sampling notwithstanding, certain biogeogeographic and ecological patterns, tendencies, and apparent anomalies are evident.

DISTRIBUTION AND ABUNDANCE

Ischnura aurora is the only zygopteran recorded among these islands where it is known only from Pingelap Atoll, apparently confined to wet areas in the large (10.12 ha) taro patch on the main island. Mokil has a smaller (3.24 ha) community taro pit and other much smaller pits covering up to several dozen square meters are scattered among the different islands. Pingelap, and possibly Mokil, may provide the only suitable habitat for this species, which is characteristically found in wet marshy areas along river banks and grass and weed-filled drainage ditches on the nearest high islands, Kosrae and Pohnpei.

Of the six Anisoptera recorded from these atolls, *Agrionoptera sanguinolenta* is the only one with breeding populations apparently confined to the Eastern Caroline Islands, in Chuuk and Pohnpei states. A male *A. sanguinolenta* collected by Naoyuki Hikita on Haha-jima Island, Bonin Islands, Japan on 10 August 1989 and deposited in the Shimanto Dragonfly Museum, Nakamura City, Kochi Prefecture, Japan is a remarkable extralimital record of the species 2600 km north of its known breeding range (Karube and Sugimura 1997). Hikita saw at least two other examples of this species, but Karube (pers. com.) believes the species is vagrant and not a resident breeder. Karube and Sugimura (1997) suggest that these individuals may have been carried by typhoons from the south, one of which passed to the west of the Bonin Islands at the end of July and the other to the east in early August 1989.

The scarcity of *Diplacodes bipunctata* among the atolls is somewhat unexpected in view of its widespread occurrence throughout Micronesia (Liefstinck 1962), including its abundance in lowland habitats on nearby Pohnpei (Paulson and Buden 2003). However, it inhabits mainly broad, open, sparsely vegetated areas and recently disturbed sites showing much bare ground; the few scattered wells and cisterns in the settlements and the shaded pools on these predominately forested or wooded atoll islets may provide only limited suitable habitat.

The apparent absence of *Pantala flavescens* on Ant atoll is a greater anomaly. This vagile, nearly cosmopolitan species is very common on nearby Pohnpei (Paulson and Buden 2003), occurs in the most distant (from source populations) atolls of Micronesia in the Marshall Islands (Jackson 1968), and is the only odonate to have colonized the world's most remote island, Easter Island, in the South Pacific (Samways and Osborn 1998). It was also one of four species to have

Table 2: Number of specimens (% in parentheses) of odonate species collected on Ant and Pingelap atolls during different times of the year.

Species	Ant Atoll			Pingelap Atoll	
	May	Sep	Nov	Mar/Apr	Dec
<i>Ischnura aurora</i>	0	0	0	3 (11.5)	0
<i>Anax guttatus</i>	6 (28.6)	1 (5.9)	4 (12.9)	0	0
<i>Agrionoptera sanguinolenta</i>	2 (9.5)	4 (23.5)	5 (16.1)	0	0
<i>Diplacodes bipunctata</i>	0	0	0	1 (3.9)	2 (7.1)
<i>Pantala flavescens</i>	0	0	0	18 (69.2)	15 (53.6)
<i>Tholymis tillarga</i>	4 (19.0)	1 (5.9)	0	1 (3.9)	3 (10.7)
<i>Tramea transmarina</i>	9 (42.9)	11 (64.7)	22 (71.0)	3 (11.5)	8 (28.6)
Total	21 (100)	17 (100)	31 (100)	26 (100)	28 (100)

colonized formerly waterless Cousine Island, Seychelles, in the Indian Ocean in just over two years following the construction of artificial pools for the island's tortoises and threatened endemic birds (Samways 1998). The time of transfer of the modular water tanks to the Ant Atoll hotel construction site and the excavation of a pit penetrating the fresh water lens was in 2000 (Robert Nanpei, pers. com.). This area of Nikalap Aru is a focal point for odonate populations on Ant Atoll; I saw no odonates on the other islands. Almost certainly *P. flavescens* has reached Ant from Pohnpei, and probably on more than one occasion, but apparently has not become permanently established. Possibly it is being excluded by other species. The one dragonfly on Ant that was tentatively identified as *P. flavescens* was intercepted and chased out of sight by a *Tramea transmarina* patrolling the area around the water tanks.

Nearly all the odonate records from these four atolls are from the main islands and at or near the settlements, where there is a relative abundance of fresh water. The only records from the outer islands are one *Agrionoptera sanguinolenta* from a broken cistern at an isolated residence on Osetik Island, Pakin Atoll, another collected at a small taro patch on Urak Island, Mokil Atoll, at least two *Pantala flavescens* in coastal strand on Teke Island, Pingelap Atoll, and an exuvia of *Tholymis tillarga* recovered from a disused cistern on Manton Island, Mokil.

SEASONALITY

Several Mokilese told me that when dragonflies are most abundant on their atoll is the best time to fish for flying fish (roughly January-March). Interestingly, the largest concentrations of dragonflies encountered during this study were on Pingelap Atoll during late March-early April when *Pantala flavescens* were

numerous on patrol over the main roads or lanes through the settlement, and all 18 specimens collected were males. None of the atolls was visited enough times during the year to assess seasonality adequately, but populations on Pingelap were sampled on two different occasions during March/April and December and Ant Atoll was surveyed three times in May, September, and November. The results of these few multiple visits suggest that the fauna of the two atolls differs in species composition and that the most abundant species on each atoll remain so throughout the year (Table 2), but additional surveys are needed to confirm this hypothesis. Evidence of breeding pooled from all four atolls suggests that it probably occurs year-round or at least over a wide span of months. The warm year-round temperatures and lack of any distinct wet or dry season would appear to foster year-round breeding, but comments of the Mokilese regarding dragonfly/flying fish relationship and the abundance of *Pantala flavescens* on Pingelap in March and April indicates the breeding patterns may be more complex.

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