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LIFE HISTORY AND ECOLOGY OF THE DRAGONFLIES (ODONATA:ANISOPTERA) OF SAN SALVADOR, BAHAMAS

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ABSTRACT

Dragonflies (Odonata:Anisoptera) are a relatively common feature of the San Salvadoran landscape and while there have been odonate collections from San Salvador in the past, none have addressed the anomaly of where these organisms are coming from and how the aquatic nymphal stage survives on what is generally characterized as a "dry" island.

Collections of dragonfly adults in January 1992 and 1993 confirm that at least nine of the thirteen previously reported species are present on the island. One additional species was found as a nymph in January 1993 (among at least six species of nymphs, perhaps the first nymphs documented on San Salvador). A preliminary examination of the aquatic fauna suggests that although diversity is high, the proportion of dragonflies to potential prey is similar to that found in other studies.

Given the apparent scarcity of breeding habitats on San Salvador, habitat destruction is of concern related to dragonfly abundance and diversity.

INTRODUCTION

Aquatic insects are distinguished as a group of insects that spend some part of their life history in an aquatic setting. Generally these organisms live entirely underwater and have distinct adaptations for such an existence. Dragonflies are typical of this group, as their eggs are normally deposited in the water or on plants, where they hatch into the immature stage (nymph). Some dragonflies may spend as little as several months in this aquatic stage until they metamorphose into adults; others like those in the family Aeshnidae spend one to two years. These immature stages are completely aquatic and generally are not found in temporary streams or ponds. The few exceptions to these generalizations include a group which lays its eggs (oviposits) on mud (Dunkle, 1976), and another which oviposits in plant stems above the water's surface (Corbet, 1980). There is one Australian dragonfly species which is reported to be terrestrial in its later instars, and two other subalpine species which can apparently survive out of the water for up to a month or so (Corbet, 1980).

At least 13 species of dragonflies are known from San Salvador, however collections have been sporadic and/or less than recent. The earliest collections date from Calvert (1909) and the most recent complete survey was done by Paulson (1966). Included in this species list are several of the long-lived dragonflies that are known from the United States where they have been documented to spend at least a full year developing in lakes or ponds. Because there is at best only a limited supply of temporary (or seasonal) fresh surface water on San Salvador, the question of where and how these odonates develop is quite interesting.

Based upon some preliminary observations three hypotheses were examined:

a) Dragonfly nymphs do not develop on the island, the adults are immigrants.
b) Dragonfly nymphs develop on the island in "non-traditional" sorts of

aquatic habitats such as sinkholes which fill with water following the rainy season, or blue holes which may become less saline during and following the rainy season (Edwards *et al.*, 1990).

c) If dragonflies develop on the island then an adequate supply of prey items must exist.

METHODS

Collection Sites and Methods

Field collections of adults and nymphs were made in January 1992 and 1993, and in May 1993. Additionally, specimens in the collection at Bahamian Field Station (BFS) and individual nymphs collected by other investigators have been included. Adult collections centered around the northwestern side of the island, with extensive efforts at the Australian Pine Marsh (APM) and the Airport Marsh (AM) (Figure 1). Adults were collected with nets, usually around/in the APM and AM areas. Other adults have been sporadically collected elsewhere, and to date, none of these collections have turned up species that were not found at the two primary sites. Adult flight behavior was also observed at the marshes in January of 1992 and 1993.

The marshes (APM and AM), Little Lake, the upper end of Pigeon Creek, numerous blue hole ponds, and sink holes (both on northwestern and southern end of the island) have been examined for nymphs. Nymphs have also been collected in samples of the aquatic fauna at the two primary dragonfly sites and coincidentally as part of fish collections in Little Lake and Blue Hole #2 (M. Barton, January 1993, personal communication). Physical examinations of the substrate and other benthic material in sinkholes (with standing water) as well as swim-overs have also been done as a means of locating nymphs.

A checklist of the dragonfly collection to date is shown as part of Table 1.

Aquatic Faunal Sampling

The APM marsh is located south of the BFS, along the eastern side of the Queens Highway. This former quarry has partially filled with silt and appears to be permanent, at least from January 1992 to late June 1993. It hosts apparently healthy populations of southern cattail (*Typha domingensis* Pers.) and spikerush (*Eleocharis cellulosa* Torr.), primarily around the margins, with *Chara* sp. and a mat-forming blue-green alga (Order Nostocales) in the center. The marsh covers approximately 800 m^2 and has a maximum depth of approximately 0.75m.

In January 1993, samples of the bottom substrate and aquatic vegetation in the APM marsh were taken to quantify the diversity and density of the aquatic fauna. Ten randomly located grab samples (three in the cattail area and seven in the spikerush) of the vegetation and substrate (each ~300 cm^2) were removed and the organisms separated, preserved in ethanol and identified to the family level. Salinity measurements were taken in all aquatic habitats examined.

RESULTS

Of the 13 species of dragonflies recorded for San Salvador, the Cuban Darner (*Gynacantha ereagris* Gundlach), the Twilight Darner (*Triacanthagyna trifida* Rambur) and the Three-striped Skimmer (*Micrathyria didyma* Selys) have not been collected in the present study (Table 1). The others, with the exception of the Vermilion Glider (*Tramea abdominalis* Rambur) are represented by both nymphs and adults.

Dragonfly nymphs have been collected in a variety of aquatic habitats on San Salvador, ranging from fresh to saline. All species found, except for the Seaside Dragonlet (*Erythrodiplax berenice* Drury), have been collected in the freshwater marshes (avg. salinity 1.6 ppt, Jan. 1992 and 1993). Two specimens of *E. berenice* were collected in more saline waters (Little Lake, salinity 32 ppt; M. Barton, pers. communication) and in Blue Hole #2 (salinity 23 ppt; M. Barton, pers. communication). Several other blue hole

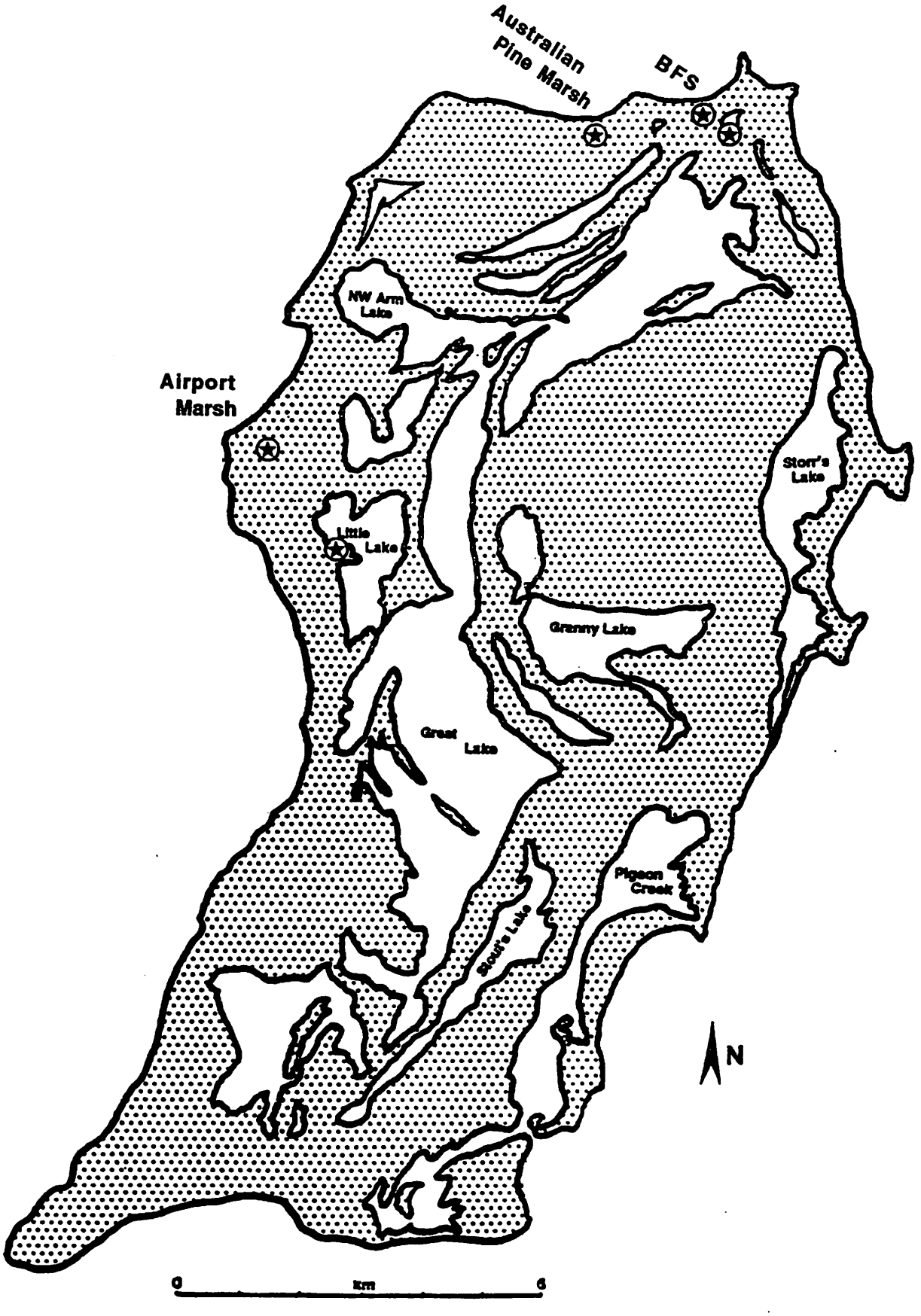


Figure 1. Map of San Salvador, Bahamas showing major collecting sites.

Table 1. Checklist of dragonflies (Odonata:Anisoptera) from San Salvador (Bahamas) based on historical and present collections.

	C	W	P	E	S/S
Order Odonata: Anisoptera					
Family Aeshnidae					
Anax longipes concolor **Brauer**	A		A	A	A, N
Gynacantha ereagris **Grundlach**	A		A		
Triacanthagyna trifida **Rambur**	A		A		
Family Libellulidae					
Orthemis ferruginea **Fabricius**	A			A	A
Brachymesia furcata **Hagen**	A		A		A
Micrathyria didyma **Selys**	A		A		
Erythrodiplax berenice **Drury**	A				A, N
Erythrodiplax umbrata **Linneaus**		A	A	A	A
Erythemis simplicicollis **Say**	A				A, N
Tramea abdominalis **Rambur**	A	A	A		N
Tramea binotata **Rambur**		A	A	A	A, N(?)
Tramea onusta **Hagen**	A	A	A		A, N(?)
Pantala flavescens **Fabricius**	A		A		A, N

C - Calvert (1909)
W - Westfall (1960)
P - Paulson (1966)
E - Elliott (1987)
S/S - present study (1992 - 1993)

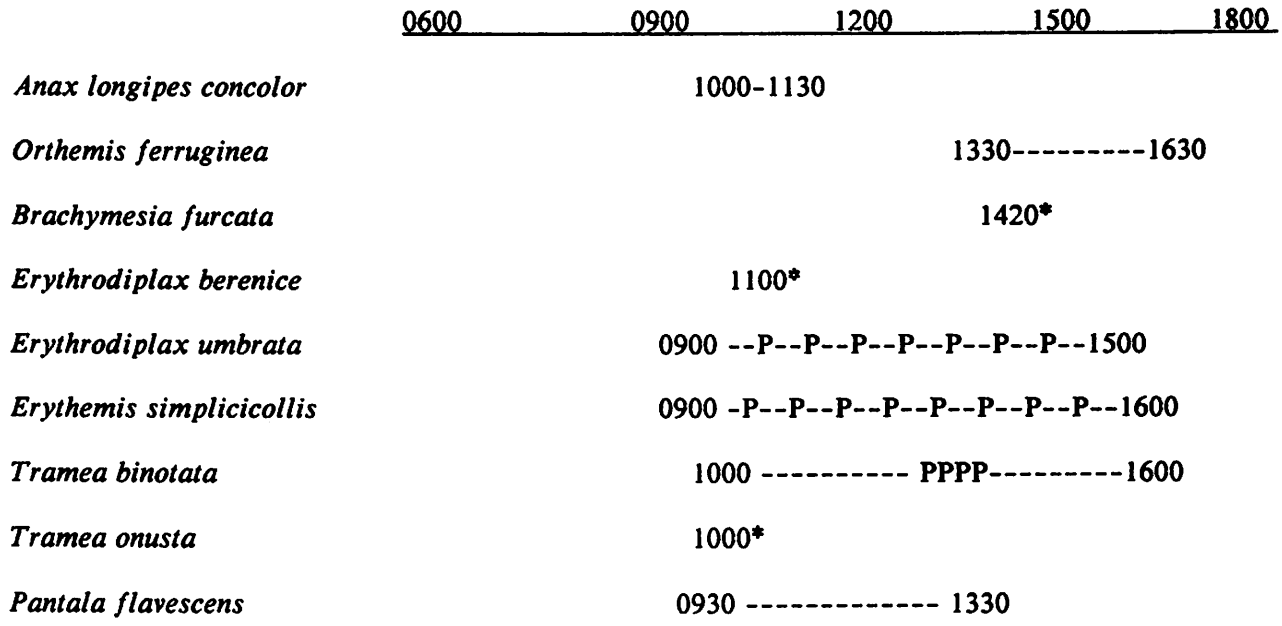
A - adults collected
N - nymphs collected
(?) - identification not confirmed

ponds (Reckley Hill Pond, Crescent Pond, Pain Pond, Watlings' Castle Blue Hole) have been sampled but no other nymphs have been located. Numerous sinkholes located between the BFS and the Line Hole Settlement have been investigated and, despite the fact that several were found which might hold water on a permanent basis, none were observed to have either nymphs or adults.

Observation and collection times of adult dragonflies have been put together to describe activity patterns (Figure 2). During the January observations, none of the species were observed to fly before 0900 hours and they seemed to disappear by 1630 hours (dawn ~0600 and dusk ~1800 hours). While most of the species were commonly seen throughout the day, the Blue-waisted Darner (*Anax longipes concolor* Brauer) was only observed to fly in the late morning hours and the Roseate Skimmer (*Orthemis ferruginea* Fab.) was only observed in the mid to late afternoon. Several of the species continuously flew (no perching observed) throughout the time they were observed (*A. l. concolor*, *O. ferruginea*, and the Wandering Glider *Pantala flavescens* Fab.) while the others perched on stems for much of the time that they were observed.

The aquatic organisms present in the APM provide a clue as to the types of food the dragonfly nymphs have access to (Table 2). Damselflies and dragonflies (Odonata) and the

Figure 2. Dragonfly activity periods, January 1992 and 1993. Sunrise during this period was approximately 0600 and sunset was at approximately 1800 hrs.



* - denotes only a single collection/observation
P - denotes perching of adults as main activity, flying only when challenged or disturbed

flies (Diptera) make up the major groups of organisms found, with the true bugs (Hemiptera), amphipods (Amphipoda), beetles (Coleoptera), and annelids comprising the rest of the fauna (Figure 3). The total number of organisms collected in these areas was small (57 individuals/10 samples or 1900/m^2), with fewer individuals in the cattails (x = 3/sample or 100/m^2) than in the spikerush (x = 7/sample or 233/m^2). The Shannon Diversity index (H') was 0.93 (maximum of 1.00), with a richness of 14 (at family taxon) and evenness of 0.81(maximum of 1.00).

DISCUSSION

A comparison of our collecting results to those of past investigators suggests that some dragonflies may not be presently found on the island. While this is certainly a possibility, since the island is substantially more developed and populated than it was during the last large survey in 1966, there may be another explanation. Dunkle (1989) states that two of three "missing" species (the darners), are crepuscular in nature and tend to favor more wooded areas. It is therefore possible that our collecting efforts have not been sufficient to document the continued presence of these species on San Salvador. Time and a continued collection effort should reveal whether these organisms are among the missing or are simply less conspicuous than the other dragonflies.

While it is known that some species of dragonflies can develop under the constraints of a temporary water supply, it is also known that most do not. The survey of aquatic habitats discussed here is not yet sufficient to thoroughly document where dragonflies are developing on the island, but it does confirm that some species are reproducing here.

The sinkholes, perhaps the most transient of the aquatic habitats on San Salvador, have yet to yield any dragonfly nymphs. To date,

Table 2. Macroinvertebrates found in the quantitative sampling of Australian Pine Marsh (APM), January 1993.

Annelida
- Oligochaeta

Arthropoda
- Malacostraca
  - Amphipoda
    - Talitridae
- Insecta
  - Odonata
    - Aeshnidae, Libellulidae, Coenagrionidae
  - Hemiptera
    - Hebridae, Belastomatidae, Naucoridae, Notonectidae, Corixidae, Veliidae
  - Coleoptera
    - Dytiscidae
  - Diptera
    - Chironomidae, Culicidae, Tabanidae

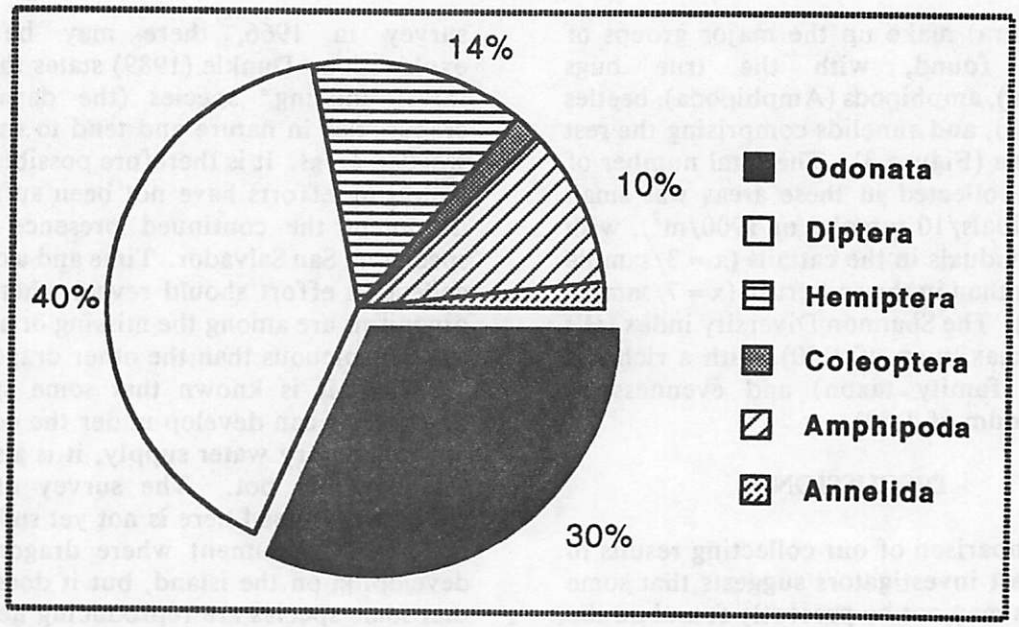


Figure 3. Dragonfly potential prey items from ten quantitative grab samples collected in APM (January 1993).

the inland lakes and the blue holes have been found to contain the only salt-water dragonfly species known, *E. berenice*. This dragonfly is known from mangrove swamps and salt marshes, as well as certain saline lakes in the western United States (Dunkle 1989). It appears however that the salt tolerances of dragonfly nymphs have not been well documented, so it may be possible that a further examination of the blue holes may yield other species of nymphs. The freshwater marshes seem to be the focal point for the majority of species, with juvenile specimens of most of the currently known species being represented (except *E. berenice*). While it is possible that more freshwater marshes exist on San Salvador than we have discussed here, they appear at this time to be a very rare habitat. This is particularly true considering the recent, apparently negative impact of the new Club Med and Airport Expansion Project on the marsh next to the airport runway.

There seems to be little literature on the seasonal presence of dragonflies on San Salvador. Dunkle (1989) suggested that based upon evidence for Florida, the species known from San Salvador might fly year round, i.e. adults continually emerging. However, casual observations suggest that this may not be true. At least, there is a greater abundance of adults observed during the late spring (May and June) than during December. Likewise, the fact that adults of several species (*O. ferruginea*, *B. furcata*, *E. umbrata*) have been collected in December, near the marshes, but that no nymphs have yet been found suggest that the nymphs may be developing earlier in the year. Similarly, *T. abdominalis* is known from a nymph, but adults have not yet been collected. While San Salvador has a warmer, perhaps more consistent climate than Florida, the winter and spring may be better months for dragonflies because it is cooler.

Although preliminary, the activity periods described here (*sensu* Lutz and Pittman, 1970), are consistent with what is known about these species: that some are "perchers" and some are "cruisers", and flight behavior may vary with temperature. The larger species (*A. l. concolor*, *O. ferruginea*, *B. furcata*) seem to avoid the hottest part of the day while the others that are out all day seem to perch a great deal during the midday period. Again, casual observations suggest that the overall activity of the dragonflies is greatest in the early morning and late afternoon hours, with a number of the species not obvious at midday. Many dragonflies are thought to be able to thermoregulate either heliothermally (heat shedding postures) or endothermically by alternating between gliding and powered flight and by altering circulation between the thorax and abdomen (May, 1976). If the heat of a sub-tropical climate affects the body temperature of San Salvadoran dragonflies, then the sort of activity periods observed here as well as the dragonflies' apparent seasonality is not unreasonable.

The faunal assemblage collected from the APM is quite diverse, as might be expected from this sub-tropical habitat. While dipterans do not make up a large percentage of the fauna, they and the other non-odonate invertebrates probably provide sufficient food items. This is a result of 1) high prey turnover rates (Menzie, 1982); 2) the fact that while a dragonfly nymph can consume up to 30% of its body weight per day in prey, it seldom feeds at this rate (Benke, 1976); 3) odonates' high food energy assimilation rate (~90%); and 4) the fact that much of the time odonate nymphs are inactive (Benke, 1976). Folsom and Collins (1982) have demonstrated that food limitation is usually minimal and that it doesn't vary significantly either seasonally or between habitats. It is therefore common to see odonates comprising a large percentage of the invertebrate fauna.

This preliminary survey of the dragonflies and their habitat on San Salvador has raised more questions than it has answered. While it is now clear that these organisms can reproduce on the island, the mechanisms by which they do this require a great deal of illumination. It is likewise clear that freshwater marshes represent a limited and fragile resource on San Salvador. If the environmental pressures usually brought about by growing population and development become evident here, then this resource and its odonate inhabitants will surely be among the early casualties.

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