Abundance and distribution variation of dragonflies in a salt marsh in response to hydrology and daily ambient temperature

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Introduction

A salt marsh is an estuarine ecosystem characterized by low-lying grassy areas subject to periodic tidal flooding. In a salt marsh a pattern of zonation is readily observable. This pattern reflects changes in relative elevation and hydrology. A mainland marsh can be subdivided into three transitional states in accordance to these changes: low marsh, mid marsh and high marsh. (Christian et al., 2000) At the Virginia Coastal Reserve Brownsville marsh, this hydromorphological continuum begins at the edge of a tidal creek, known as Phillip's Creek. Similar to all low marsh areas, this region is dominated by halophytic plants, in this case *Spartina alterniflora* (tall form) (Adams, 1963). A terrestrial forest area borders the Brownsville marsh and thus, the zonation ends as the high marsh transgresses into the forest (Christian et al., 2000). This transitional area illustrates the invasion of upland vegetation as a result of sea-level rise and is characterized by stunted *Juniperus virginiana* and a mixture of marsh grasses including *Distichlis spicata* and *Spartina patens*. The high marsh consists of facultative halophytes including *Juncus roemerianus* and *S. patens* as well as salt obligates such as *D. spicata* (Adams 1963). The mid-marsh area exists between the high and low marsh extremes and is co-dominated by all four marsh grass species. Both the high and mid-marsh areas vary in terms of hydrogeomorphologies and patterns of species associations (Christian et al., 2000). Many of these associations that exist along the continuum from low marsh to high marsh can be categorized into "sub-habitats" of similar species composition, hydrology and geomorphology.

Variation in hydrogeomorphology between the habitats creates variation in species composition in both flora and fauna. More specifically, the community structures of insects are influenced by changes in hydrology (Batzer, 1996). One diverse insect community particularly sensitive to fluctuations in water level and plant community is that of the Odonates (dragonflies and damselflies). Dragon and damselflies are highly dependent on water because they spend the larval stage of their life cycle in an aqueous environment. Access to water is essential for the survival of these insects. For this reason, Odonates are typically predominant in wetland areas that flood for long periods of time (Batzer, 1996).

Odonates are also dependant on warmth and sunlight for numerous activities including flying. The flight muscles of these insects function best at high temperatures: large aechnids (e.g. Green Darners) are unable to fly at temperatures below 30-40°C, whereas libellulids (e.g. Common Whitetails) prefer body temperatures of 24°C (Vogt et.al, 1983). In response to this need for warmth Odonates have developed behavioral, morphological and physiological adaptations to regulate their body temperature. Dragonflies classified as "perchers" (e.g. *Ischnura sp.*) bask in the sunlight or on warm rock or earth to sequester heat. Conversely, flies dubbed "flyers" (e.g. *Anax sp.*) achieve elevated temperatures by wing-whirring (shivering flight muscles while perched) (Dunkle, 2000). Depending on the ambient temperature and amount of radiation, the rate of activity will fluctuate—on sunny days and at higher temperatures more activity (flying and foraging) will be observed than on cold grey days (Miller, 1987).

There is a large diversity and abundance of Odonates in the mainland marshes of the Virginia Coastal Reserve. While working in the marsh I began to notice increased diversity and profusion of dragon and damselflies in certain areas with in the marsh, particularly areas with standing water. I began to question if variation in the distribution and abundance between the various sub-habitats truly existed. My project attempts to juxtapose the availability of standing water and time of day by observing the variation in distribution and abundance between the seven identified sub-habitats at three times of day: morning, midday and evening—using time of day as a surrogate for temperature.

I postulated that the greatest diversity and abundance would exist in areas with standing water. Furthermore, because Odonates prefer warmer temperatures, I predicted to see greater abundance and diversity at midday when temperatures are generally the highest.

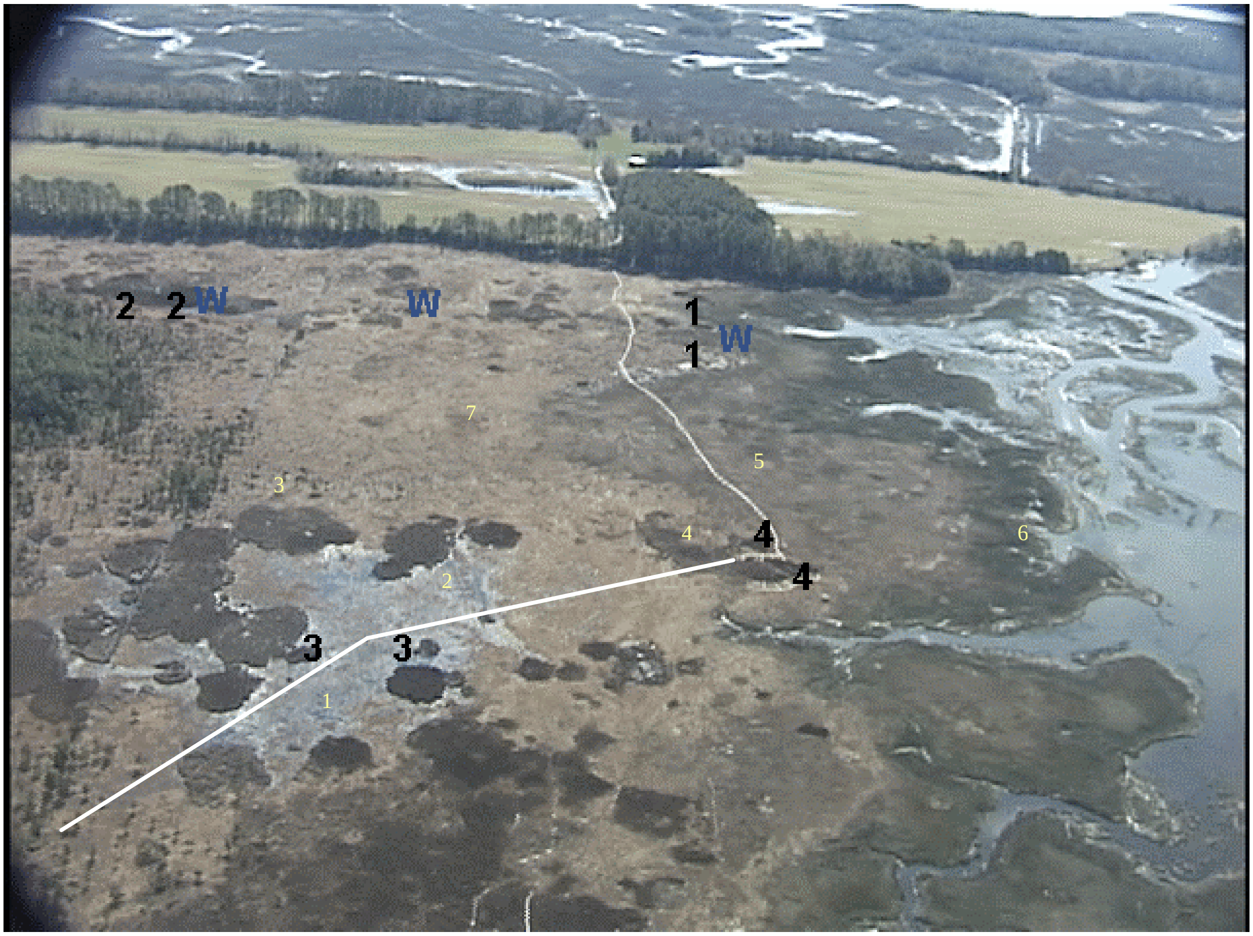


Figure 1. Phillips Creek marsh and location of sampling sites.

Materials and Methods

<u>Study site and habitats</u>

The researched marsh is a part of the Virginia Coast Reserve. The Brownsville Upper Phillip's Creek marsh is located on the Delmarva Peninsula in Virginia USA (37° 27'N 75° 50'W) and lies between a predominantly conifer forest on the mainland to the southwest and a field-covered Pleistocene ridge to the northeast (Brinson et al. 1995). Tidal inundation from Phillip's Creek floods from the south with a mean amplitude of 1.45m (Hmieleski 1994 as cited in Christian et. al 2000). For the purposes of this research seven habitats were identified in this area (Figure 1).

The first habitat was the creek bank. This area, habitat 6, was dominated by *S. alterniflora* (tall form) and was the most influenced by tidal fluctuations because of its close proximity to the creek. The next region, habitat 5, was located approximately 100m from the creek bank. This area was the second most influenced by tidal inundation and was dominated by *S. alterniflora* (short form). Habitats 4 and 7 were similar in distance from the tidal creek, approximately 300m, but showed distinctly different species compositions, dominated by *J. roemerianus* and a mixture of *D. spicata* and *S. patens*, respectively. Both of these mid-marsh habitats were relatively unaffected by tidal changes, with the exception of spring tides, during which an increased water level was observed. Two of the remaining three habitats had constantly standing water. Habitat 2 contained two 30mx2m ponds bordered by a mixture of *D. spicata* and *S. patens*, while the second inundated area, habitat 1, was composed of unstable turf that created a hummock and hollow pattern. The species composition in this habitat was a mixture of *D. spicata*, *S. patens* and *J. roemerianus*. Finally, habitat 3 was the transition area between the high marsh and the terrestrial forest. In this transitional region the floral composition was a mixture of *D. spicata* and *S. patens* as well as *Iva frutescens* and stunted *Juniperius virginiana*.

Measurements

A 30-m long transect was established in each habitat. Five non-overlapping points were chosen randomly using a random numbers table and surveyed. The observer stood stationary at each point for five minutes and counted the number of Odonates in a 1.5-m radius circle. In effect, each transect was surveyed for twenty-five minutes. This constituted a single sampling—so that the total number of flies and number of species were summed. I also observed the behavior of the flies, i.e. if they were perched or flying and mating or single. This data was not analyzed but is included in the appendix (Appendices II-V). Five minutes was established by trial and error to be the time at which the maximum amount of flies could be counted with the minimum amount of overlapping between habitats (Appendix I). A 1.5-m long muslin insect net with a 38-cm metal ring supporting a 71-cm deep muslin bag was used to measure the radius. These measurements were taken at three times of day: morning (sun rise until 11:00am), midday (12:00pm until 4:00pm) and evening (5:00pm until sun set). Time of day was used as a surrogate measurement for temperature under the assumption that temperature would be highest during the mid-day period. This assumption was generally accurate (Figure 2). Samples were only taken on sunny days. Each habitat was measured three times per site and time of day, so that the total number of samples taken at each habitat was 9. Since the amount of wind can affect fly activity the presence or absence of a breeze was recorded. Samples were taken through out the month of July. An additional sample was taken in September but the variation in results was too great to include with the July samples (Appendices II-V).

The data was initially entered into Microsoft Excel. It was then transferred to SPSS and analyzed using a two-way analysis of variance (ANOVA) on abundances and distribution among habitats and times of day. I used the post-hoc LSD test to group habitats that were statistically similar during each time of day.

Results

Table 1 lists the common and scientific name of the species identified and counted in the Brownsville marsh in order of decreasing abundance. The most prolific species was *Eythrodiplax berenice*. It was found in 87.5% of all samplings. The next two most common species were *Ischnura ramburii* and *Libellula lydia*, seen in 37.5% and 28.75% of samples respectively. The rest of the species were observed in 15% of samples or less. The total number of flies varied greatly between different habitats (Table 2). The habitats with the largest mean abundance of flies through all time periods were those with standing water–pond region (habitat 1) and hummock and hollow area (habitat 2). The mean number of flies in these habitats, 19.0 and 19.9 respectively, was not significantly different than that of the *J. roemerianus* habitat (4) which had a mean of 17.7. The forest transition, creek bank (*S. alterniflora* tall form) and the low marsh (*S. alterniflora* short form) habitats (3, 5 and 6) had respective means of 8.4, 8.7 and 9.3. These values, showed abundances similar to each other but significantly different than the habitats with standing water (habitats 1 and 2) as well as the *J. roemerianus* habitat (4). Habitat 7, the mid-marsh *D. spicata* and *S. patens* mix region, showed a mean abundance of 10.7, which differed significantly from habitats 1 and 2 but not from habitat 4. An ANOVA test supported the data's significance giving a value of .017 that the variation between the habitats was greater than the variation within the individual habitats.

Furthermore, variation was observed at different times of day. The general trend was a greater abundance at mid-day when temperatures were highest. This trend held true for all habitats with the exception of habitat 4 (Table 3). Composed of predominantly *J. roemerianus*, habitat 4 showed the highest mean in the morning. However, this mean showed no statistical significance. The total mean abundances (all habitats) were 11.7 (morning), 19.3 (midday) and 9.1 (evening). Where as the mean for the *J. roemerianus* habitat were 23.7, 14.0 and 15.3. Over all the habitats an LSD test showed that significant difference in Odonate abundance between morning and mid-day and between evening and mid-day, but not between morning and evening.

I also analyzed distribution of taxa and found statistically significant variation among habitats. The two habitats with standing water, i.e. the ponds (1) and hummock and hollow (2) regions, were statistically similar to one another and to the forest transition (3) and showed the highest mean abundances among habitats. The respective mean distribution values were 4.9, 4.3 and 3.7 taxa. The forest transition mean was not statistically different from the predominantly *J. roemerianus* habitat (4) mean, 2.3. This habitat (*J. roemerianus*) was statistically similar to all habitats excluding those with standing water (1 and 2). The remaining habitats, low marsh (*S. alterniflora* short, habitat 5, creek bank (*S. alterniflora* tall, habitat 6) and mid-marsh (*D. spicata* and *S. patens* mixed, habitat 7), were statically similar to one another and to the *J. roemerianus* habitat (4). They were statistically different than the standing water habitats (1 and 2). The respective mean distribution values of these habitats were 1.7, 1.1 and 1.7.

Different times of day showed no statistically significant differences in diversity across all habitats. That is there was no significant variation in distribution across habitats with respect to sampling times: morning, midday and evening. The total diversity values (across all habitats) ranged from 5.3 in the hummock and hollow habitat to 1.1 in the creek bank habitat. In example, there was also no statistically significant difference in diversity within habitats. Three mean distribution values for the hummock and hollow habitat (1) were 5.3 (morning), 5.3 (midday) and 4.0 (evening). The difference in these values was not large enough to be considered significant. This closeness of mean diversity values was a trend through all habitats.

Table 1. Species list of Odonates found and measured in the Brownville marsh during research

Common Name	**Scientific Name**	**Frequency (%)**
Seaside Dragonlet	*Eythrodiplax berenice*	87.5
Rambur's Forktail	*Ischnura ramburii*	37.5
Needham's Skimmer	*Libellula needhami*	28.75
Common Whitetail	*Libellula lydia*	15.0
Great Blue Skimmer	*Libellula vibrans*	12.25
Spangled Skimmer	*Libellula cyanea*	10.0
Twelve-Spotted Skimmer	*Libellula pulchella*	10.0
Common Green Darner	*Anax junius*	10.0
Powdered Dancer	*Argia moesta*	10.0
Unknown	*Enallagma sp.*	8.75
Flame Skimmer	*Libellula saturata*	8.75
Black Saddlebags	*Tramea lacerata*	7.5
Unknown	*Ischnura sp.*	6.25
Citrine forktail	*Ischnura hastata*	5
Unknown	*Enallagma sp.*	1.25

Figure 2. Graph of average temperature vs. time of day

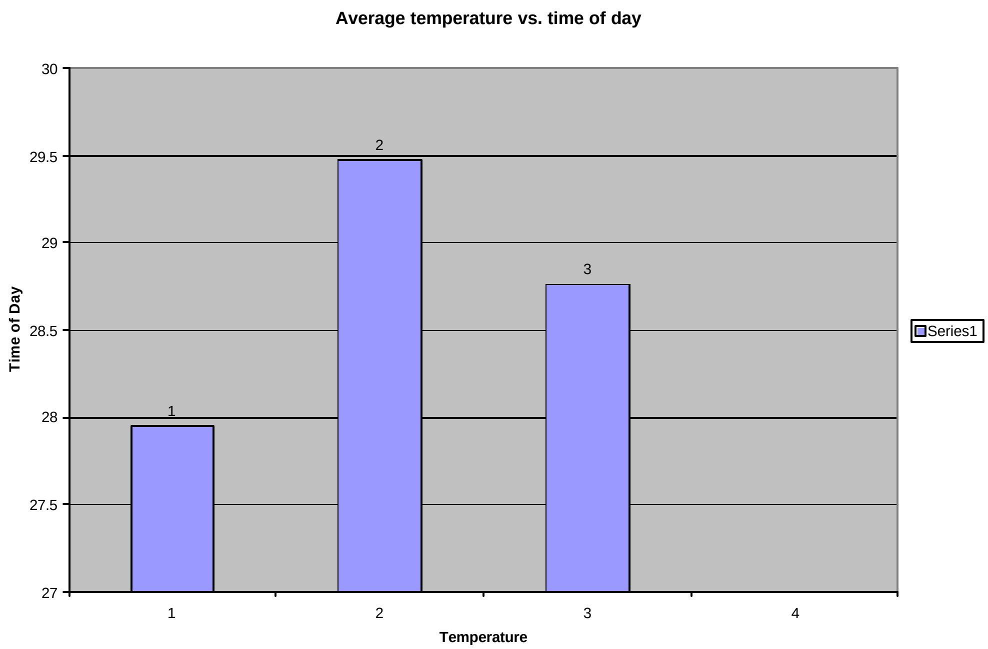


Table 2. LSD analysis of abundance between habitats

(I) HABITAT	(J) HABITAT	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	-.8889	3.5292	.802	-8.0110	6.2333
	3.00	10.5556	3.5292	.005	3.4334	17.6777
	4.00	1.3333	3.5292	.707	-5.7888	8.4555
	5.00	10.3333	3.5292	.005	3.2112	17.4555
	6.00	9.6667	3.5292	.009	2.5445	16.7888
	7.00	8.3333	3.5292	.023	1.2112	15.4555
2.00	1.00	.8889	3.5292	.802	-6.2333	8.0110
	3.00	11.4444	3.5292	.002	4.3223	18.5666
	4.00	2.2222	3.5292	.532	-4.8999	9.3444
	5.00	11.2222	3.5292	.003	4.1001	18.3444
	6.00	10.5556	3.5292	.005	3.4334	17.6777
	7.00	9.2222	3.5292	.012	2.1001	16.3444
3.00	1.00	-10.5556	3.5292	.005	-17.6777	-3.4334
	2.00	-11.4444	3.5292	.002	-18.5666	-4.3223
	4.00	-9.2222	3.5292	.012	-16.3444	-2.1001
	5.00	-.2222	3.5292	.950	-7.3444	6.8999
	6.00	-.8889	3.5292	.802	-8.0110	6.2333
	7.00	-2.2222	3.5292	.532	-9.3444	4.8999
4.00	1.00	-1.3333	3.5292	.707	-8.4555	5.7888
	2.00	-2.2222	3.5292	.532	-9.3444	4.8999
	3.00	9.2222	3.5292	.012	2.1001	16.3444
	5.00	9.0000	3.5292	.015	1.8779	16.1221
	6.00	8.3333	3.5292	.023	1.2112	15.4555
	7.00	7.0000	3.5292	.054	-.1221	14.1221
5.00	1.00	-10.3333	3.5292	.005	-17.4555	-3.2112
	2.00	-11.2222	3.5292	.003	-18.3444	-4.1001
	3.00	.2222	3.5292	.950	-6.8999	7.3444
	4.00	-9.0000	3.5292	.015	-16.1221	-1.8779
	6.00	-.6667	3.5292	.851	-7.7888	6.4555
	7.00	-2.0000	3.5292	.574	-9.1221	5.1221
6.00	1.00	-9.6667	3.5292	.009	-16.7888	-2.5445
	2.00	-10.5556	3.5292	.005	-17.6777	-3.4334
	3.00	.8889	3.5292	.802	-6.2333	8.0110
	4.00	-8.3333	3.5292	.023	-15.4555	-1.2112
	5.00	.6667	3.5292	.851	-6.4555	7.7888
	7.00	-1.3333	3.5292	.707	-8.4555	5.7888
7.00	1.00	-8.3333	3.5292	.023	-15.4555	-1.2112
	2.00	-9.2222	3.5292	.012	-16.3444	-2.1001
	3.00	2.2222	3.5292	.532	-4.8999	9.3444
	4.00	-7.0000	3.5292	.054	-14.1221	.1221
	5.00	2.0000	3.5292	.574	-5.1221	9.1221
	6.00	1.3333	3.5292	.707	-5.7888	8.4555

Table 3. Analysis of abundance at different times of day

HABITAT	TIME	Mean	Std. Deviation	N
1.00	1.00	15.0000	9.8489	3
	2.00	25.6667	13.3167	3
	3.00	16.3333	6.5064	3
	Total	19.0000	10.2225	9
2.00	1.00	10.3333	4.0415	3
	2.00	35.0000	14.0000	3
	3.00	14.3333	3.7859	3
	Total	19.8889	13.7154	9
3.00	1.00	7.0000	3.6056	3
	2.00	11.0000	6.5574	3
	3.00	7.3333	3.7859	3
	Total	8.4444	4.6128	9
4.00	1.00	23.6667	6.3509	3
	2.00	14.0000	9.1652	3
	3.00	15.3333	9.0738	3
	Total	17.6667	8.5000	9
5.00	1.00	4.0000	4.3589	3
	2.00	19.0000	2.0000	3
	3.00	3.0000	3.6056	3
	Total	8.6667	8.3217	9
6.00	1.00	13.3333	6.8069	3
	2.00	12.6667	8.6217	3
	3.00	2.0000	2.6458	3
	Total	9.3333	7.8899	9
7.00	1.00	8.6667	5.5076	3
	2.00	17.6667	12.0968	3
	3.00	5.6667	4.0415	3
	Total	10.6667	8.8034	9
Total	1.00	11.7143	7.9759	21
	2.00	19.2857	11.7096	21
	3.00	9.1429	7.2200	21
	Total	13.3810	10.0200	63

Table 4. LSD analysis of distribution between habitats

(I) HABITAT	(J) HABITAT	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
1.00	2.00	.5556	.7052	.435	-.8677	1.9788
	3.00	1.2222	.7052	.090	-.2010	2.6454
	4.00	2.5556	.7052	.001	1.1323	3.9788
	5.00	3.2222	.7052	.000	1.7990	4.6454
	6.00	3.7778	.7052	.000	2.3546	5.2010
	7.00	3.2222	.7052	.000	1.7990	4.6454
2.00	1.00	-.5556	.7052	.435	-1.9788	.8677
	3.00	.6667	.7052	.350	-.7566	2.0899
	4.00	2.0000	.7052	.007	.5768	3.4232
	5.00	2.6667	.7052	.000	1.2434	4.0899
	6.00	3.2222	.7052	.000	1.7990	4.6454
	7.00	2.6667	.7052	.000	1.2434	4.0899
3.00	1.00	-1.2222	.7052	.090	-2.6454	.2010
	2.00	-.6667	.7052	.350	-2.0899	.7566
	4.00	1.3333	.7052	.066	-8.9886E-02	2.7566
	5.00	2.0000	.7052	.007	.5768	3.4232
	6.00	2.5556	.7052	.001	1.1323	3.9788
	7.00	2.0000	.7052	.007	.5768	3.4232
4.00	1.00	-2.5556	.7052	.001	-3.9788	-1.1323
	2.00	-2.0000	.7052	.007	-3.4232	-.5768
	3.00	-1.3333	.7052	.066	-2.7566	8.989E-02
	5.00	.6667	.7052	.350	-.7566	2.0899
	6.00	1.2222	.7052	.090	-.2010	2.6454
	7.00	.6667	.7052	.350	-.7566	2.0899
5.00	1.00	-3.2222	.7052	.000	-4.6454	-1.7990
	2.00	-2.6667	.7052	.000	-4.0899	-1.2434
	3.00	-2.0000	.7052	.007	-3.4232	-.5768
	4.00	-.6667	.7052	.350	-2.0899	.7566
	6.00	.5556	.7052	.435	-.8677	1.9788
	7.00	-2.2204E-16	.7052	1.000	-1.4232	1.4232
6.00	1.00	-3.7778	.7052	.000	-5.2010	-2.3546
	2.00	-3.2222	.7052	.000	-4.6454	-1.7990
	3.00	-2.5556	.7052	.001	-3.9788	-1.1323
	4.00	-1.2222	.7052	.090	-2.6454	.2010
	5.00	-.5556	.7052	.435	-1.9788	.8677
	7.00	-.5556	.7052	.435	-1.9788	.8677
7.00	1.00	-3.2222	.7052	.000	-4.6454	-1.7990
	2.00	-2.6667	.7052	.000	-4.0899	-1.2434
	3.00	-2.0000	.7052	.007	-3.4232	-.5768
	4.00	-.6667	.7052	.350	-2.0899	.7566
	5.00	2.220E-16	.7052	1.000	-1.4232	1.4232
	6.00	.5556	.7052	.435	-.8677	1.9788

Table 5. Analysis of distribution at different times of day

TIMEODAY	HABITAT	Mean	Std. Deviation	N
1.00	1.00	5.3333	3.7859	3
	2.00	5.0000	1.7321	3
	3.00	4.6667	1.5275	3
	4.00	1.6667	1.1547	3
	5.00	1.0000	.0000	3
	6.00	1.0000	.0000	3
	7.00	2.0000	1.0000	3
	Total	2.9524	2.3765	21
2.00	1.00	5.3333	1.1547	3
	2.00	5.3333	2.3094	3
	3.00	3.0000	2.6458	3
	4.00	2.3333	.5774	3
	5.00	2.3333	.5774	3
	6.00	1.6667	1.1547	3
	7.00	2.0000	.0000	3
	Total	3.1429	1.9310	21
3.00	1.00	4.0000	1.0000	3
	2.00	2.6667	1.1547	3
	3.00	3.3333	2.0817	3
	4.00	3.0000	.0000	3
	5.00	1.6667	1.5275	3
	6.00	.6667	.5774	3
	7.00	1.0000	.0000	3
	Total	2.3333	1.5275	21
Total	1.00	4.8889	2.1473	9
	2.00	4.3333	2.0000	9
	3.00	3.6667	2.0000	9
	4.00	2.3333	.8660	9
	5.00	1.6667	1.0000	9
	6.00	1.1111	.7817	9
	7.00	1.6667	.7071	9
	Total	2.8095	1.9745	63

Figure 3. Graph of abundance as a function of habitat

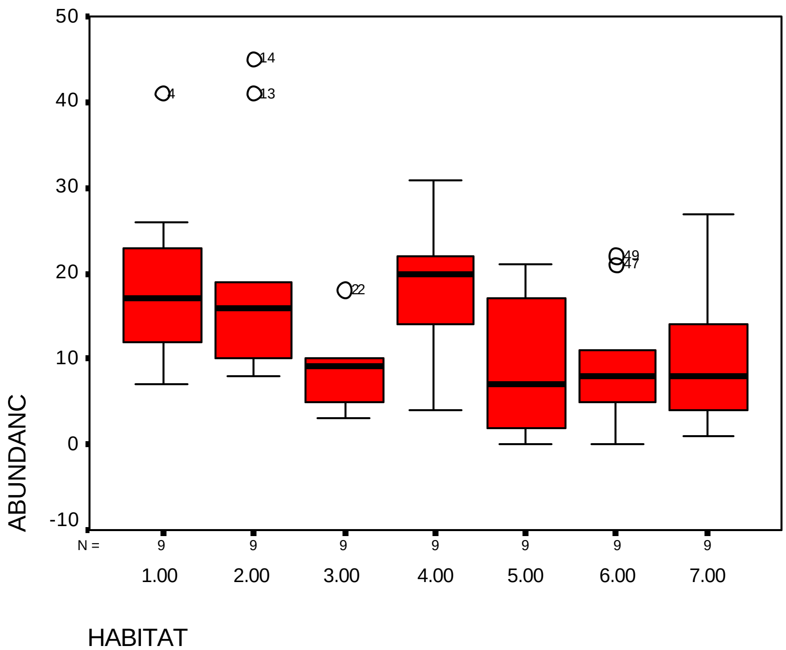


Figure 4. Graph of abundance as a function of time of day

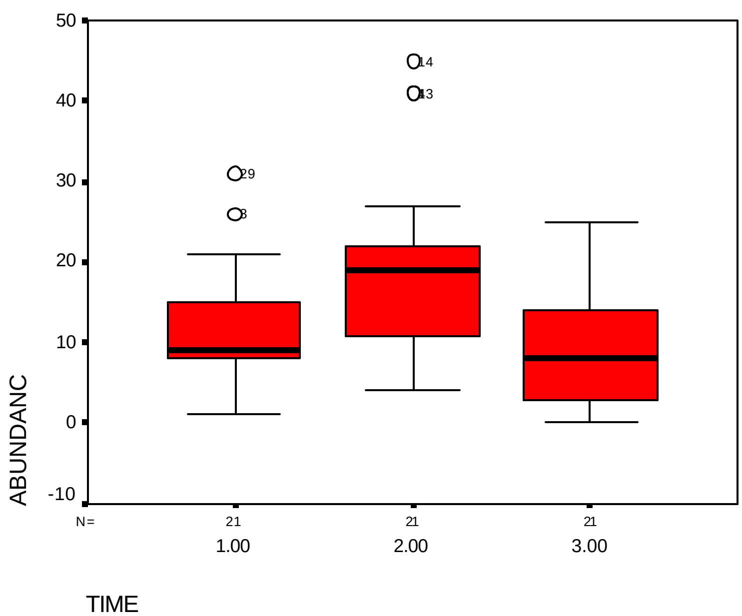


Figure 5. Graph of distribution as a function of habitat

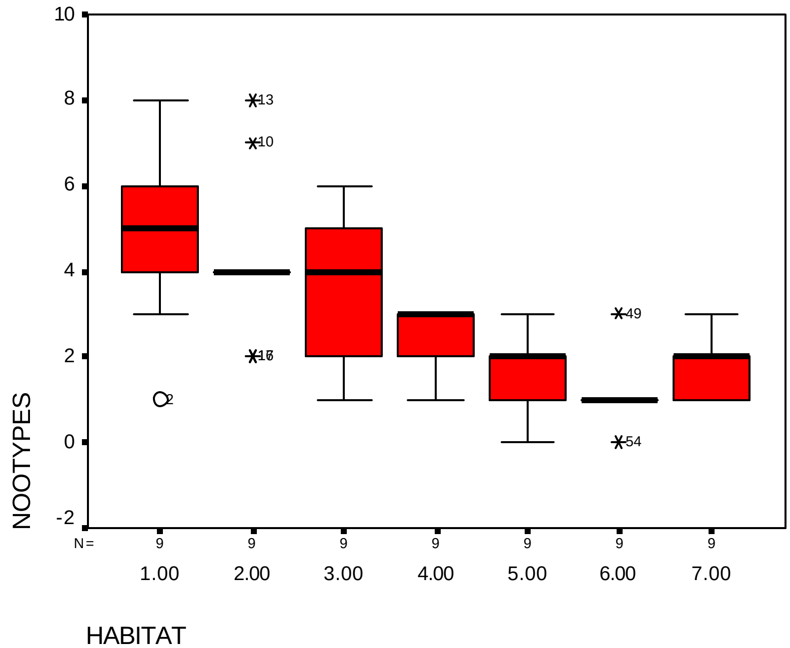
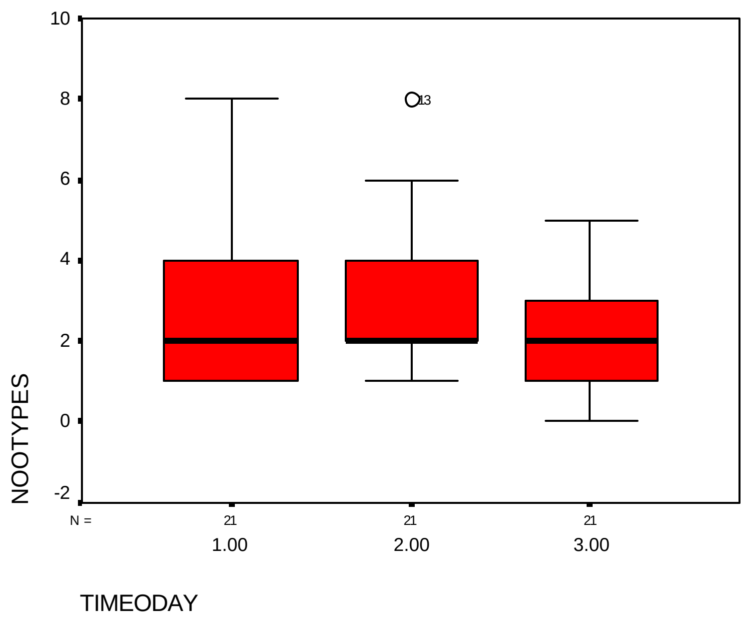


Figure 6. Graph of distribution as a function of time of day



Discussion

<u>Overview</u>

A variety of Odonates thrive in salt marsh habitats due to the amount of water and hospitable temperatures. Dragon and damselflies are largely dependant on both water and warm temperatures (Miller, 1987). They lay eggs in or near water as their larvae are aquatic. Factors that effect the distribution of larvae are water movement, pH as well as the amount and type of aquatic vegetation (Miller, 1987). Another important determinant of larval distribution is temperature (Chemlick, 1980). Thus, the species found in a salt marsh are adapted to brackish water, marsh vegetation and warm ambient temperatures. In a salt marsh, pools of standing water provide an ideal habitat for dragonfly larvae where as the vegetation provides both shelter and perching sites for adults. The lack of tree canopy allows for uninterrupted sunlight, an ideal condition for basking (Miller, 1987). (Basking is a behavioral adaptation to increase thoracic temperature.)

The overwhelmingly dominant species found in the Phillip's Creek marsh was *Eythrodiplax berenice.* Usually found in salt marshes, these rigorous flies are the only species in the Western Hemisphere that can breed in pure salt water (Dunkle, 2000). In addition to *Libellula needhami* and *Libellula Lydia*, *E. berencie* was found present in all seven microhabitats surveyed. Other species that showed high abundances were *Ischnura ramburii*, *L. needhami* and *L. lydia* All three of these species are traditionally found near slow moving or stagnant water and have high tolerances to salt (Dunkle, 2000). Several species were found almost exclusively in habitats with standing water, including*: L. lydia*, *Tramea lacerata*, and *Enallagma sp.*

I postulated that the highest abundance and diversity would exist in areas with standing water. I also postulated that the abundance and diversity would increase at midday when temperatures are generally the highest.

<u>Abundance</u>

In reference to abundance, I accept my hypothesis—abundance increased in areas with standing water and with of time of day. However, because the *J. roemerianus* showed a total mean abundance similar to the standing water habitats, it is evident that additional factors e.g. surrounding flora, influence the abundance. In the Phillip's Creek Marsh the abundance of flies was the highest in habitats with standing water and the *J. roemerianus* habitat. The mean abundance for all habitats was 13.4 where as the hummock and hollow region and the pond habitat had total mean abundances of 19.9 and 19.0 respectively. Thus, the standing water habitat's mean abundances significantly exceeded the total mean abundances of every other habitat, excluding the *J. roemerianus* habitat, whose total mean abundance was 17.7. Both the hummock and hollow region and the pond area had constant standing water and were relatively uninfluenced by the tide because of there distance from the creek (Figure 1). Conversely, the *J. roemerianus* habitat had no standing water and was subject to periodic inundation during extremely high or spring tides.

I observed a large number of basking dragonflies in the *J roemerianus* habitat and I suspect that the abundance in *J. roemerianus* rivals that of the habitats with standing water because of the plant's function as a perch. Dragonflies commonly perch at low temperatures. The least disturbance in temperature will cause dragonflies to seek shelter on non-woody plants upon which they bask (Dunkle, 2000). In the marsh, *J. roemerianus* provides an excellent medium for perching as its rigid blades grow taller than most other marsh grasses and are not vulnerable to the elements.

Abundance also showed a statistically significant overall increase at midday. The total mean abundance across all habitats increased from 11.7 in the morning to 19.3 in the afternoon and decreased again to 9.1 in the evening. However, this trend was not universal. The *J. romerianus* and creek bank habitats deviated, each showing their highest individual mean abundances in the morning. The mean morning abundance in the *J. romerianus* was highest across all habitats. Although this peak showed no statistical relevance, it is suggestive and could show significance with an increased sample size.

It is also possible to attribute the trend deviation (towards increased abundance at midday) of the *J. romerianus* and the creek bank habitat to their functional use a perches. Although not to the degree of the *J. romerianus*, I also observed perching behavior on *S. alterniflora* (tall) of the creek bank (Appendices II-III).

Diversity

In reference to diversity, I partially accept my hypothesis—diversity increased in habitats with standing water. The three habitats with the greatest diversity were the two with standing water and the forest transition habitat. The mean diversity values for the hummock and hollow habitat and pond habitat were 4.9 and 4.3 which were statistically greater than all other habitats withstanding the forest transition habitat. The mean diversity value of the forest transition area was lower, 3.7, but was not statistically different. It is not surprising that diversity favors the standing water habitats because all species of Odonates are dependant on water. The high diversity in the forest transition area was unexpected because there was no standing water in this habitat. However, the diversity in the forest transition area may be attributable to the proximity to the standing water habitats (Figure1). Dragonflies are highly mobile insects and may cruise for miles to find prey, to perch or to mate (Dunkle, 2000). The forest transition area was relatively close to the standing water habitats and it is possible that many of the inhabitants migrate to the terrestrial transition area to perch.

I reject my hypothesis that diversity would increase at midday; the results showed no increase in diversity with time of day. All dragonflies have similar habitation requirements i.e. water, warm temperatures, perching sites and therefore show the same general behavioral patterns. (Miller, 1987) It is likely that because a certain number of flies inhabit the marsh, the same species composition will be reflected in all surveys due to universal behavioral patterns.

Important points

Two issues must be addressed in my reasoning for unexpected results: 1) Both the *J. romerianus* and the creek bank habitat deviated from the general trend towards higher abundance at midday. Instead, they showed the highest mean abundance in the morning. However, the difference was more severe in the *J. romerianus* habitat. What accounts for this difference? 2) The diversity in the forest transition habitat was attributed to its functional use for perching by flies from the nearby standing water habitats. However, unlike other habitats proposed as perching habitats, the forest transition habitat complied with the general trend in increased abundance at midday. Why didn't the forest transition show elevated abundance in the morning and evening like the other projected perching habitats? I propose that the location of these habitats accounts for the results and answers both of these questions. The creek bank and the forest transition habitats are located at extremes of the marsh, where as the *J. roemerianus* habitat was located centrally (Figure 1). Thus, in addition to the plant's rigor, the observed abundance in the *J. roemerianus* was greater than the abundance in the creek bank because it was closer to a greater number of flies. Furthermore, the abundance was not reflected in the forest transition region because it was less accessible than other areas in the marsh.

Another important consideration is that in this experiment, midday was a surrogate for temperature. Temperature was postulated and accepted to cause an increase in abundance of Odonates. However, it must be recognized that in addition to temperature, a number of other variables change with respect to time of day that could potentially to influence the diversity and abundance including: increased radiation, a decrease in humidity and increased prey availability at midday. These factors were not measured or taken into account for the purposes of this research.

Conclusion

Standing water provides a stable environment for dragonflies to both lay eggs and forage. Thus, areas with standing water showed greater abundances and diversity than areas with out. In addition, Odonates are solar powered organisms that operate optimally at warm temperatures. Thus, a greater overall abundance and diversity of flies was observed at midday. However, because the *J. roemerianus* habitat showed a similar abundance and the forest transition habitat showed a similar diversity to that of the standing water habitats, it is clear that other factors influence the amount and type of dragonflies in an area. These for-mentioned variables should be included in future research experiments on the variation in abundance and distribution of Odonates.

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Appendix: Table of Contents

Appendix I. Table of various sample times

Habitat	**3 minutes**	**5 minutes**	**10 minutes**
1	14 flies, 3 species	20 flies, 5 species	19 flies, 5 species
3	3 flies, 2 species	7 flies, 3 species	8 flies, 2 species
4	7 flies, 1 species	14 flies, 3 species	15 flies, 2 species

Appendix II. Excel data on flying Odonates

HABITAT	TIMEDAY	DATE	TEMP	BREEZE	REDSKIM	DARKBLU	YELOTAIL	YTSWING	RUSTY	GRDARN	SADDLE	DUSKY	BLUDARN	WHITAIL	BLUTDAM	WHITDAM	ORGDAM	BRNDAM	G&YDAM	BLUET	12SPOT	TOTL -FLY	AVG-FLY
1	1	7/16/01	31	0	3	1	0	1	1	2	0	0	0	2	1	0	0	0	0	0	0	11	
1	1	7/20/01	24	0	0	3		0	0	0	0	0	0	0	2	0	0	0	0	0	0	5	
1	1	7/10/01	32	0	13	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0	0	17	
1	3	7/17/01	32	1	1	3	2	1	0	0	0	0	0	1	2	0	0	0	0	0	0	10	
1	2	7/12/01	29	0	15	0	10	2	1	0	0	1	0	6	4	0	0	0	0	0	0	39	
1	3	7/25/01	33	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	2	
1	2	7/9/01	29	0	3	5	0	0	0	0	0	2	1	5	3	0	0	0	0	0	0	19	
1	1	9/15/01	16	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	
1	2	9/15/01	21	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	
1	3	9/15/01	21	1	0	1	1	0	0	1	0	0	1	0	2	0	0	0	0	0	0	6	
1	3	7/23/01	29	1	0	2	2	0	0	0	0	0	0	0	3	0	0	0	0	0	0	7	
1	2	7/20/01	25	1	1	4	2	3	0	0	0	0	0	1	5	0	0	0	0	0	0	16	11.3333
2	3	7/25/01	33	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	
2	1	7/10/01	32	0	4	2	0	0	0	0	1	3	0	2	1	0	0	0	0	0	0	13	
2	2	7/12/01	29	0	4	0	10	5	0	1	0	2	1	7	9	0	0	0	0	1	0	40	
2	2	7/16/01	32	0	1	20	10	8	0	0	0	0	0	4	2	0	0	0	0	0	0	45	
2	1	7/20/01	23	1	0	1	0	0	1	0	0	0	0	0	2	0	0	0	0	0	0	4	
2	1	7/20/01	24	1	0	2	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	6	
2	3	7/23/01	28	1	0	6	1	1	0	0	0	0	0	0	5	0	0	0	0	0	0	13	
2	2	7/9/01	29	0	6	2	0	0	0	0	0	0	0	7	4	0	0	0	0	0	0	19	
2	3	7/11/01	34	0	0	5	2	0	0	0	0	0	0	4	5	0	0	0	0	0	1	17	
2	1	9/15/01	16	1	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	3	
2	2	9/15/01	21	1	1	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	5	
2	3	9/15/01	21	1	0	2	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	10	14.8462
3	1	7/11/01	29	0	4	0	0	1	0	0	1	2	0	0	0	0	0	0	0	0	0	8	
3	3	7/24/01	30	1	1	3	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	6	
3	1	7/10/01	31	0	3	0	2	0	0	0	1	0	0	0	0	1	0	0	0	0	1	8	
3	1	7/13/01	29	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

3	3	7/15/01	30	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	
3	2	7/16/01	32	0	1	7	1	2	1	0	0	0	0	0	3	0	1	0	0	0	0	16	
3	2	7/20/01	26	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	
3	2	7/23/01	30	1	0	1	6	3	0	0	0	0	0	0	0	0	0	0	0	0	0	10	
3	3	7/23/01	26	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
3	1	9/15/01	18	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	
3	2	9/15/01	22	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
3	3	9/15/01	21	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.5833
4	3	7/23/01	26	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	
4	1	7/11/01	32	1	2	6	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	10	
4	2	7/12/01	30	0	1	12	2	4	0	0	0	0	0	0	0	0	0	0	0	0	1	20	
4	1	7/16/01	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4	1	7/20/01	24	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	
4	2	7/20/01	26	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
4	2	7/9/01	27	0	2	11	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	16	
4	1	9/15/01	18	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4	2	9/15/01	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4	3	9/15/01	21	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	
4	2	7/21/01	25	1	0	4	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	7	
4	3	7/19/01	25	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	5.3333
5	2	7/10/01	33	0	0	14	3	3	0	0	0	0	0	0	0	0	0	0	0	0	1	21	
5	2	7/9/01	27	0	0	11	2	3	0	0	0	1	0	0	0	0	0	0	0	0	0	17	
5	2	9/15/01	23	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	
5	3	9/15/01	21	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
5	1	9/16/01	23	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
5	2	7/11/01	33	0	0	7	5	4	0	0	0	2	0	0	0	0	0	0	0	0	1	19	
5	1	7/12/01	29	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	
5	3	7/16/01	32	1	0	4	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	7	
5	3	7/20/01	25	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
5	3	7/19/01	26	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
5	1	7/20/01	25	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

5	1	7/21/01	25	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5.9167
6	3	7/20/01	25	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
6	2	7/10/01	32	0	1	10	4	4	0	0	0	0	0	0	0	0	0	0	0	0	1	20	
6	2	7/11/01	33	0	0	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	
6	1	7/16/01	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
6	3	7/25/01	33	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
6	2	7/13/01	32	1	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	
6	1	7/23/01	26	0	0	6	7	3	0	0	0	0	0	0	0	0	0	0	0	0	0	16	
6	1	7/25/01	25	1	0	1	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	8	
6	2	7/23/01	30	0	1	16	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	21	
6	3	7/23/01	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
6	1	9/15/01	23	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
6	2	9/15/01	23	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
6	3	9/15/01	21	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6.0769
7	2	7/9/01	27	0	4	18	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	27	
7	1	9/15/01	18	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
7	2	9/15/01	22	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	
7	3	9/16/01	21	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	
7	3	7/23/01	28	1	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	
7	1	7/23/01	26	0	0	4	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	12	
7	2	7/20/01	26	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	3	
7	1	7/11/01	29	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	
7	1	7/16/01	30	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	2	
7	3	7/15/01	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
7	2	7/16/01	32	0	0	9	7	2	0	0	0	0	0	0	0	0	0	0	0	0	0	18	
7	3	7/24/01	28	1	0	5	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	8	6.8333

Appendix III. Excel data on perched Odonates

HABITAT	TIMEDAY	DATE	TEMP	BREEZE	REDSKIM	DARKBLU	YELOTAIL	YTSWING	RUSTY	GRDARN	SADDLE	DUSKY	BLUDARN	WHITAIL	BLUTDAM	WHITDAM	ORGDAM	BRNDAM	G&YDAM	BLUET	12SPOT	TOTL -PD	AVG-PD
1	1	7/16/01	31	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	2	
1	1	7/20/01	24	0	0	1	2	1	0	0	0	0	0	0	-2	0	0	0	0	0	0	2	
1	1	7/10/01	32	0	0	2	1	1	0	0	-1	1	0	0	4	0	1	0	0	0	0	9	
1	3	7/17/01	32	1	1	3	2	1	0	0	0	0	0	1	2	0	0	0	0	0	0	10	
1	2	7/12/01	29	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	
1	3	7/25/01	33	1	1	1	11	1	0	0	0	0	0	0	7	0	0	0	0	0	0	21	
1	2	7/9/01	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1	1	9/15/01	16	1	0	0	0	0	0	0	0	0	0	0	3	0	0	1	0	0	0	4	
1	2	9/15/01	21	1	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	3	
1	3	9/15/01	21	1	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	5	
1	3	7/23/01	29	1	0	2	2	0	0	0	0	0	0	2	3	0	0	0	0	0	0	9	
1	2	7/20/01	25	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	5.6667
2	3	7/25/01	33	1	0	1	1	1	0	0	0	0	0	1	4	0	0	0	0	0	0	8	
2	1	7/10/01	32	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	
2	2	7/12/01	29	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	
2	2	7/16/01	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2	1	7/20/01	23	1	0	0	1	0	0	0	0	0	0	0	2	1	0	0	0	0	0	4	
2	1	7/20/01	24	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	2	
2	3	7/23/01	28	1	0	0	1	0	0	0	0	0	0	0	2	0	0	0	0	0	0	3	
2	2	7/9/01	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2	3	7/11/01	34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2	1	9/15/01	16	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2	2	9/15/01	21	1	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	4	
2	3	9/15/01	21	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	2.0833
3	1	7/11/01	29	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	2	
3	3	7/24/01		1	0	1	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	3	
3	1	7/10/01	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

3	1	7/13/01	29	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	3	
3	3	7/15/01	30	0	0	0	0	1	0	0	0	0	0	0	2	1	0	0	5	0	0	9	
3	2	7/16/01	32	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2	
3	2	7/20/01	26	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	
3	2	7/23/01	30	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
3	3	7/23/01	26	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	
3	1	9/15/01	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
3	2	9/15/01	22	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	
3	3	9/15/01	21	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.0000
4	3	7/23/01	26	1	0	10	6	3	0	0	0	0	0	0	0	0	0	0	0	0	5	24	
4	1	7/11/01	32	1	0	1	6	3	0	0	0	0	0	0	0	0	0	0	0	0	0	10	
4	2	7/12/01	30	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	
4	1	7/16/01	31	0	0	8	17	6	0	0	0	0	0	0	0	0	0	0	0	0	0	31	
4	1	7/20/01	24	0	0	1	12	2	0	0	0	0	0	0	0	0	0	0	0	0	0	15	
4	2	7/20/01	26	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	3	
4	2	7/9/01	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4	1	9/15/01	18	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4	2	9/15/01	22		0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
4	3	9/15/01	21	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4	2	7/21/01	25	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4	3	7/19/01	25	1	0	5	2	3	1	1	0	0	0	0	0	0	0	0	0	0	0	12	8.1667
5	2	7/10/01	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
5	2	7/9/01	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
5	2	9/15/01	23	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	
5	3	9/15/01	21	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
5	1	9/16/01	23	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
5	2	7/11/01	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
5	1	7/12/01	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
5	3	7/16/01	32	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
5	3	7/20/01	25	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	
5	3	7/19/01	26	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

5	1	7/20/01	25	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
5	1	7/21/01	25	1	0	5	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	8	1.0000
6	3	7/20/01	25	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
6	2	7/10/01	32	0	0	2	-1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	
6	2	7/11/01	33	0	0	0	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	5	
6	1	7/16/01	30	0	0	4	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	11	
6	3	7/25/01	33	1	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	
6	2	7/13/01	32	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
6	1	7/23/01	26	0	0	1	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	5	
6	1	7/25/01	25	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
6	2	7/23/01	30	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	
6	3	7/23/01	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
6	1	9/15/01	23	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
6	2	9/15/01	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
6	3	9/15/01	21	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.2308
7	2	7/9/01	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
7	1	9/15/01	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
7	2	9/15/01	22	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
7	3	9/16/01	21	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
7	3	7/23/01	28	1	0	1	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	5	
7	1	7/23/01	26	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	
7	2	7/20/01	26	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
7	1	7/11/01	29	0	0	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	3	
7	1	7/16/01	30	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
7	3	7/15/01	32	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
7	2	7/16/01	32	0	0	0	0	1	0	0	0	0	0	0	3	0	0	0	0	0	0	4	
7	3	7/24/01	28	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.4167

Appendix IV. Excel data on single Odonates

HABITAT	TIMEDAY	DATE	TEMP	BREEZE	REDSKIM	DARKBLU	YELOTAIL	YTSWING	RUSTY	GRDARN	SADDLE	DUSKY	BLUDARN	WHITAIL	BLUTDAM	WHITDAM	ORGDAM	BRNDAM	G&YDAM	BLUET	12SPOT	TOTAL#	AVG-SIN
1	1	7/16/01	31	0	3	1	0	1	1	2	0	0	0	2	1	0	0	0	0	0	0	11	
1	1	7/20/01	24	0	0	4	0	1	0	0	0	0	0	0	2	0	0	0	0	0	0	7	
1	1	7/10/01	32	0	12	2	1	1	0	0	1	0	1	1	5	0	1	0	0	0	0	25	
1	3	7/17/01	32	1	1	3	2	1	0	0	0	0	0	1	2	0	0	0	0	0	0	10	
1	2	7/12/01	29	0	4	0	10	2	1	0	0	1	0	6	3	0	0	0	0	0	0	27	
1	3	7/25/01	33	1	1	1	11	1	0	1	1	0	0	0	5	0	0	0	0	0	0	21	
1	2	7/9/01	29	0	3	3	0	0	0	0	0	2	1	5	3	0	0	0	0	0	0	17	
1	1	9/15/01	16	1	0	1	0	0	0	0	0	0	1	0	3	0	0	1	0	0	0	6	
1	2	9/15/01	21	1	0	1	0	0	0	0	0	0	1	0	3	0	0	0	0	0	0	5	
1	3	9/15/01	21	1	0	0	1	0	0	1	0	0	1	0	7	0	0	0	0	0	0	10	
1	3	7/23/01	29	1	0	4	4	0	0	0	0	0	0	2	6	0	0	0	0	0	0	16	
1	2	7/20/01	25	1	1	3	2	2	0	0	0	0	0	1	6	0	0	0	0	0	0	15	14.1667
2	3	7/25/01	33	1	0	2	1	1	0	0	0	0	0	1	3	0	0	0	0	0	0	8	
2	1	7/10/01	32	0	5	2	0	0	0	0	1	2	0	2	1	0	0	0	1	0	0	14	
2	2	7/12/01	29	0	4	0	2	1	0	1	0	0	1	7	8	0	0	0	0	1	0	25	
2	2	7/16/01	32	0	1	4	2	8	0	0	0	0	0	4	0	0	0	0	0	0	0	19	
2	1	7/20/01	23	1	0	1	1	0	1	0	0	0	0	0	4	1	0	0	0	0	0	8	
2	1	7/20/01	24	1	0	2	0	0	0	0	0	0	0	0	4	1	0	0	1	0	0	8	
2	3	7/23/01	28	1	0	6	2	1	0	0	0	0	0	0	5	0	0	0	0	0	0	14	
2	2	7/9/01	29	0	6	0	0	0	0	0	0	0	0	7	4	0	0	0	0	0	0	17	
2	3	7/11/01	34	0	0	5	2	0	0	0	0	0	0	4	5	0	0	0	0	0	1	17	
2	1	9/15/01	16	1	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	3	
2	2	9/15/01	21	1	1	0	0	0	0	0	1	0	0	0	4	0	0	0	0	0	1	7	
2	3	9/15/01	21	1	0	2	0	0	0	0	0	0	0	0	8	0	0	1	0	0	0	11	12.5833
3	1	7/11/01	29	0	4	0	0	1	0	0	1	0	0	0	1	0	1	0	0	0	0	8	
3	3	7/24/01		1	1	4	0	1	0	0	0	0	0	0	0	0	1	2	0	0	0	9	
3	1	7/10/01	31	0	3	0	2	0	0	0	1	0	0	0	0	1	0	0	0	0	1	8	

3	1	7/13/01	29	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	3	
3	3	7/15/01	30	0	0	0	0	1	0	0	1	0	0	0	2	1	0	0	5	0	0	10	
3	2	7/16/01	32	0	1	5	1	0	1	0	0	0	0	0	3	1	1	0	0	0	0	13	
3	2	7/20/01	26	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	
3	2	7/23/01	30	1	0	1	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	8	
3	3	7/23/01	26	1	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	
3	1	9/15/01	18	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	
3	2	9/15/01	22	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	
3	3	9/15/01	21	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.8333
4	3	7/23/01	26	1	0	10	6	3	0	1	0	0	0	0	0	0	0	0	0	0	5	25	
4	1	7/11/01	32	1	2	5	4	4	0	1	0	0	0	0	0	0	0	0	0	0	0	16	
4	2	7/12/01	30	0	1	6	2	2	0	0	0	0	0	0	0	0	0	0	0	0	1	12	
4	1	7/16/01	31	0	0	8	17	6	0	0	0	0	0	0	0	0	0	0	0	0	0	31	
4	1	7/20/01	24	0	0	6	12	2	0	0	0	0	0	0	0	0	0	0	0	0	0	20	
4	2	7/20/01	26	1	0	2	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	4	
4	2	7/9/01	27	0	2	9	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	14	
4	1	9/15/01	18	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4	2	9/15/01	22	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
4	3	9/15/01	21	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	2	
4	2	7/21/01	25	1	0	4	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0	7	
4	3	7/19/01	25	1	0	6	2	3	1	2	0	0	0	0	0	0	0	0	0	0	0	14	12.1667
5	2	7/10/01	33	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	
5	2	7/9/01	27	0	0	7	2	1	0	0	0	1	0	0	0	0	0	0	0	0	0	11	
5	2	9/15/01	23	0	0	0	3	0	0	0	0	0	0	0	1	0	0	0	0	0	0	4	
5	3	9/15/01	21	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
5	1	9/16/01	23	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
5	2	7/11/01	33	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	
5	1	7/12/01	29	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	
5	3	7/16/01	32	1	0	4	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	7	
5	3	7/20/01	25	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	
5	3	7/19/01	26	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

5	1	7/20/01	25	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
5	1	7/21/01	25	1	0	5	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	9	3.6667
6	3	7/20/01	25	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
6	2	7/10/01	32	0	1	6	1	5	0	0	0	0	0	0	0	0	0	0	0	0	1	14	
6	2	7/11/01	33	0	0	1	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	9	
6	1	7/16/01	30	0	0	4	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	11	
6	3	7/25/01	33	1	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	
6	2	7/13/01	32	1	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	
6	1	7/23/01	26	0	0	3	10	2	0	0	0	0	0	0	0	0	0	0	0	0	0	15	
6	1	7/25/01	25	1	0	1	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0	8	
6	2	7/23/01	30	0	1	13	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	17	
6	3	7/23/01	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
6	1	9/15/01	23	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
6	2	9/15/01	23	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
6	3	9/15/01	21	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.0654
7	2	7/9/01	27	0	4	18	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	27	
7	1	9/15/01	18	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
7	2	9/15/01	22	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	
7	3	9/16/01	21	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	
7	3	7/23/01	28	1	0	2	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	8	
7	1	7/23/01	26	0	0	2	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	10	
7	2	7/20/01	26	0	1	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	4	
7	1	7/11/01	29	0	0	7	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	9	
7	1	7/16/01	30	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	0	0	0	3	
7	3	7/15/01	32	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
7	2	7/16/01	32	0	0	0	2	1	0	0	0	0	0	0	3	0	0	0	0	0	0	6	
7	3	7/24/01	28	1	0	5	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	8	6.5833

Appendix V. Excel data on tandem Odonates

HABITAT	TIMEDAY	DATE	TEMP	BREEZE	REDSKIM	DARKBLU	YELOTAIL	YTSWING	RUSTY	GRDARN	SADDLE	DUSKY	BLUDARN	WHITAIL	BLUTDAM	WHITDAM	ORGDAM	BRNDAM	G&YDAM	BLUET	12SPOT	TOTL-TAN	AVG-TAN
1	1	7/16/01	31	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	2	
1	1	7/20/01	24	0	0	0	2	0	0	0	0	0	0	0	-2	0	0	0	0	0	0	0	
1	1	7/10/01	32	0	1	0	0	0	0	0	-1	1	0	0	0	0	0	0	0	0	0	1	
1	3	7/17/01	32	1	1	3	2	1	0	0	0	0	0	1	2	0	0	0	0	0	0	10	
1	2	7/12/01	29	0	12	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	14	
1	3	7/25/01	33	1	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2	
1	2	7/9/01	29	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	
1	1	9/15/01	16	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1	2	9/15/01	21	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1	3	9/15/01	21	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
1	3	7/23/01	29	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1	2	7/20/01	25	1	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2.8333
2	3	7/25/01	33	1	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2	
2	1	7/10/01	32	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	
2	2	7/12/01	29	0	0	0	8	4	0	0	0	2	0	0	2	0	0	0	0	0	0	16	
2	2	7/16/01	32	0	0	16	8	0	0	0	0	0	0	0	2	0	0	0	0	0	0	26	
2	1	7/20/01	23	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2	1	7/20/01	24	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2	3	7/23/01	28	1	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2	
2	2	7/9/01	29	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	
2	3	7/11/01	34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2	1	9/15/01	16	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
2	2	9/15/01	21	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	
2	3	9/15/01	21	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.2500
3	1	7/11/01	29	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2	
3	3	7/24/01		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
3	1	7/10/01	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

3	1	7/13/01	29	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
3	3	7/15/01	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
3	2	7/16/01	32	0	0	2	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	5	
3	2	7/20/01	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
3	2	7/23/01	30	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	
3	3	7/23/01	26	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
3	1	9/15/01	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
3	2	9/15/01	22	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
3	3	9/15/01	21	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7500
4	3	7/23/01	26	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4	1	7/11/01	32	1	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	
4	2	7/12/01	30	0	0	6	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	10	
4	1	7/16/01	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4	1	7/20/01	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4	2	7/20/01	26	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4	2	7/9/01	27	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	
4	1	9/15/01	18	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4	2	9/15/01	22		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4	3	9/15/01	21	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4	2	7/21/01	25	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
4	3	7/19/01	25	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.3333
5	2	7/10/01	33	0	0	12	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	18	
5	2	7/9/01	27	0	0	4	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	6	
5	2	9/15/01	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
5	3	9/15/01	21	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
5	1	9/16/01	23	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
5	2	7/11/01	33	0	0	6	3	4	0	0	0	2	0	0	0	0	0	0	0	0	0	15	
5	1	7/12/01	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
5	3	7/16/01	32	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
5	3	7/20/01	25	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
5	3	7/19/01	26	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

5	1	7/20/01	25	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
5	1	7/21/01	25	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.2500
6	3	7/20/01	25	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
6	2	7/10/01	32	0	0	6	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	
6	2	7/11/01	33	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	
6	1	7/16/01	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
6	3	7/25/01	33	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
6	2	7/13/01	32	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
6	1	7/23/01	26	0	0	4	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	6	
6	1	7/25/01	25	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
6	2	7/23/01	30	0	0	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	
6	3	7/23/01	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
6	1	9/15/01	23	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
6	2	9/15/01	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
6	3	9/15/01	21	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.6923
7	2	7/9/01	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
7	1	9/15/01	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
7	2	9/15/01	22	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
7	3	9/16/01	21	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
7	3	7/23/01	28	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
7	1	7/23/01	26	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	
7	2	7/20/01	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
7	1	7/11/01	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
7	1	7/16/01	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
7	3	7/15/01	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
7	2	7/16/01	32	0	0	9	5	2	0	0	0	0	0	0	0	0	0	0	0	0	0	16	
7	3	7/24/01	28	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.6667