Guyana Days: Collecting in the Northern Guyana Shield

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Introduction

South America hosts amazing diversity. The Smithsonian Institution has run an exploration program documenting the biodiversity of the Guyana Shield (BDG; Venezuela, Guyana, French Guyana, Suriname, and Brazil) since 1983. Historically, the BDG program has focused on mammals (primarily done by Mark Engstrom and Burton Lim), birds (such as the remarkable reference, "A Field Checklist of the Birds of Guyana" by Michael J. Braun, Davis W. Finch, Mark B. Robbins, and Brian K. Schmidt), and plants, (e.g., "Checklist of the Plants of the Guianas" now in its second edition, edited by J. Boggan, V. Funk, C. Kelloff, M. Hoff, G. Cremers, & C. Feuillet). We recently began exploring the Odonata of the Guyana Shield.

The Odonata of French Guyana has been documented (e.g., Fleck, 2003), as have odes from Venezuela (e.g., DeMarmels, 1983, 1991, 1993, 1998, 1999) and Brazil (e.g., Calvert, 1948; Ferreira-Perquetti et al., 2003; Costa et al., 2010; Pinto & Einicker, 2010). In the twentieth century, several dragonfly and damselfly taxa from British Guyana may have been included in faunal surveys but no comprehensive study of British Guyana has been undertaken since Calvert (1948b; and it was not comprehensive but rather focused on Odonata from Bartica, Guyana). Indeed, distribution maps for many species show ranges surrounding, but not including Guyana, due to what is almost surely sampling-bias (Garrison et al., 2006).

We first traveled to Guyana to collect odes in July 2011, and followed up that trip with a second visit in January 2012. Our goal for working in the Guyana Shield is to document the biodiversity of odes in the country, knowing that this will take several years (an exciting prospect)!

General Habitat

The northern and coastal section of Guyana is covered in rainforest; although simply referring to it as rainforest would not be truly descriptive of the habitat. There is quite a bit of heterogeneity to the terrestrial landscape. The hilly land is a mosaic of upland and lowland rainforest, dotted with swampy regions, as well as active and abandoned farmland.

Melissa Sanchez-Herrera and our Guyanese volunteers Sheri-Ann Ashanti, Celena, and Sheneeza.

Much of the lowland rainforest is in the primary successional stage with large trees towering 24 to 30 meters above the forest floor. The lowlands also have standing water in some areas, which create islands of swamp surrounded by thick jungle. The uplands are considerably dryer and have less of a jungle feel. The soil is largely composed of sand throughout the coastal regions. When the effect of the porous soil works in concert with elevation, the higher regions display more xeric characteristics, despite the regular rain.

Although Guyana is largely uninhabited, the coastal areas do have a significant population of people. Despite the lack of nutrient and water holding ability of the soil much of the populated land is dedicated to slash and burn farming. Although this is obviously ecologically undesirable, it does provide feeding habitat for odonates that we can easily access and exploit for collection.

CEIBA Biological Station

On these first two trips we visited CEIBA Biological Station, Linden Highway, Madewini. CEIBA is a biological field station, situated on primarily farmland and secondary growth forest. There are several tributaries nearby, as well as a spring, allowing for great opportunities to observe female oviposition and male territoriality in Odonata. Aeshnidae hawk over fields, Gomphidae patrol

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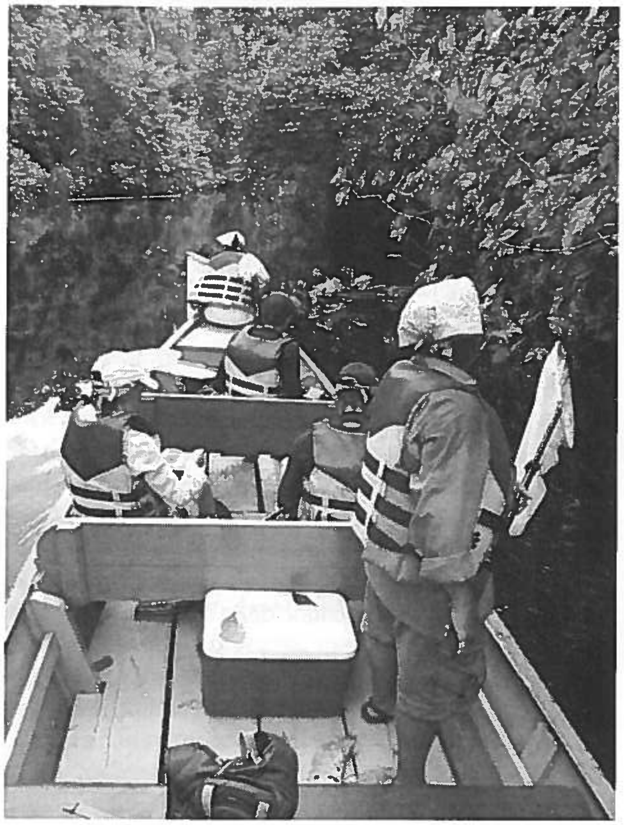

Ian Biazzo and Manpreet Kaur Kohli collecting on a tributary of the Demerara River.

small creeks, *Zenithoptera* perch on branches overhead and elusive helicopter damselflies have been occasionally spotted near the entrance to a deep swath of primary forest.

Epiphytic bromeliads are a common feature of the forest strata in many tropical rainforest habitats. In this regard, Northern Guyana is not atypical. However, what is atypical is the stark absence of odonate larvae present within. We have dissected dozens of these aquatic microcosms and have discovered a fauna of beetle and fly larvae, various cockroaches, tarantula and other spiders, but no aquatic predators, including damsel larvae. It is no surprise then that we have had little luck catching adult Psuedostigmatids in the same areas. Psuedostigmatid damselflies are specialized for oviposition in bromeliads and tree holes. As a result, searching for larvae in these microhabitats should yield significant catch, as has been shown in other similar habitats (Srivastava, 2006; pers. obs.; Fincke, 2006). As we continue to sample the shield, we hope to get a better idea of the distribution of these damsels across the country, and come to a better understanding of where they are more or less abundant. We've collected (or spotted) *Mecistogaster*, but have not yet seen *Megaloprepus* or other members of this family, and then only as adults (no larvae have yet been found).

Demerara River and Santa Mission

West of CEIBA is a tributary of the Demerara River which leads to the Amerindian Village of Santa Mission. The tributary is surrounded by forest that is either intact or cut down by people who have converted it to farmland. As you travel deeper down the tributary the landscape opens up into wide grassy and shrubby meadows. All along the tributary is a fine place for catching unique damselflies and dragonflies. In fact, some of our most difficult hunting occurs while floating down the river on our small boat.

Catching dragonflies on the river takes a great deal of patience and dexterity. One will usually have but one chance to get close to them before they fly away. The first swipe of the net is likely your only chance to catch the ode, so one better be a good aim. The larger dragonflies on the Demerara Tributary were mostly found perching on branches that hang over the water. These were usually not so difficult to catch as we had the forward trajectory of the boat adding to our swing speed. However, the job was difficult when we encountered dragonflies that fly up and down the river at high speeds. We tracked them from about 20 meters away in order to be ready for them. Everyone stretched their necks following the tiny insect across the cacophony of leaves and branches. Even with up to seven net wielding entomologists in a boat, chances were slim that these rapid river fliers would be caught. This is magnified by the fact that these larger species are a rare sight in the heat of the day. In fact,

Sorting bromeliad samples, looking for larvae. Joseph Evangelista, Dominic Evangelista, Ian Biazzo, Paul Franden, Jessica Ware and our Guyanese volunteers Sheri-Ann Ashanti, Celena, Zafiniah and Sheneeza.

we have found that maybe the best time for catching them is when the sun is going down. The dragonflies at this time (mostly Corduliidae, Libellulidae and Aeshnidae) would fly back and forth over the same general area to feed on the insects emerging at twilight. We've found that collecting in Guyana requires the longest net, the highest reach, and pure luck that the dragonfly is directly above you at the moment you swing your arms.

Species list: what we collected

Our sampling is biased, in that J.W. was especially focused on catching Libelluloidea, and M.S.H. was actively searching for Zygoptera. M.K.K. tried several methods to collect Aeshnidae, from mist nets in fields (which yielded one specimen) and hand-made weights on twine, which she threw into the air to attract adults. We hope that seasonal and environmental biodiversity differences will become apparent over our future years of sampling.

Anisoptera

Aeshnidae
- *Coryphaeschna* sp.
- *Gynacantha* sp.

Libellulidae
- *Dythemis* sp.
- *Diastatops intensa*
- *Erythemis vesiculosa*
- *Erythemis peruviana*
- *Erythemis* sp.
- *Elasmothemis* sp.
- *Erythrodiplax umbrata*
- *Erythrodiplax fervida*
- *Erythrodiplax* sp.
- *Miathyria simplex*
- *Orthemis* sp.
- *Pantala flavescens*
- *Perithemis* sp.
- *Zenithoptera* sp.

Zygoptera

Coenagrionidae
- *Acanthagrion* sp.
- *Aeloagrion dorsale*
- *Telebasis demarara*
- *Ischnura* sp.
- *Leptobasis* sp.

We wish to warmly thank the members of the CEIBA research team, especially Joyce Wade. Thanks also to Karen Redden for all of her guidance about working in Guyana. Thanks also to our boat driver, Rakesh Bybye, who was an excellent swing with a net on the boat and to Mrs. Chanasue for organizing our trip(s). We can't wait to get back to Guyana!

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Archilestes grandis (Great Spreadwing) and *Sympetrum rubicundulum* (Ruby Meadowhawk), Two New Records for Montana

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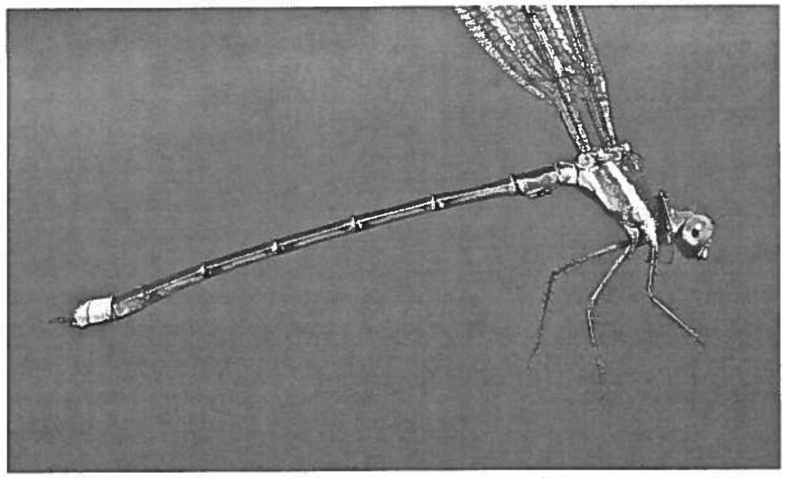
Archilestes grandis (Great Spreadwing): During a visit to the Little Bighorn River south of Crow Agency in Big Horn County on 2 September 2011, I captured one male *A. grandis* (OC# 332803).



Archilestes grandis (Great Spreadwing), male. Little Bighorn River, Big Horn Co., Montana. 2 September 2011

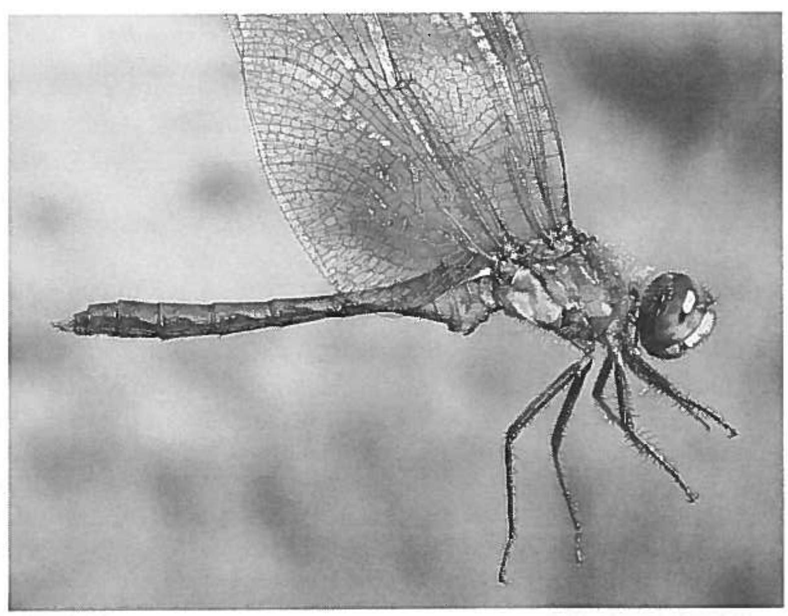
When first spotted from some 15 feet away, perched low in some vegetation near the stream, I recognized immediately that it was a spreadwing, and more than twice the size of any that I had seen previously in Montana. Assuming that it was most likely *A. grandis*, and coupled with the fact that it could be a new record for the state, you can imagine my nervousness as I approached cautiously. The capture went off without a hitch, and in retrospect it turned out to be a good thing, because it was the only individual found during the three hours that I explored the area.

The Little Bighorn River at this location is a fair-sized, semi-clear stream with a moderate flow. The vegetation along the river is predominantly cottonwood and sand bar willow. In areas, the sandy stream banks are lined by grasses and small amounts of rush. During my visit I found the stream level to be surprisingly high for this late in the season, and very few exposed gravel bars were present. Of the nine odonate species detected in the area on this date, *Hetaerina americana* (American Rubyspot) was by far the most common, virtually omnipresent and more abundant than I have observed anywhere else in Montana.

Although this record represents the furthest north that *A. grandis* has ever been documented, it is not all that far removed from the known range, and one species which I, and others, had expected to possibly occur in southeast Montana (Miller & Gustafson, 1996). The nearest known records are from Teton County, Wyoming to the southwest (Molnar & Lavigne, 1979) and Custer County, South Dakota to the southeast (Donnelly, 2004a).

A look at the dates from other nearby records indicate that *A. grandis* probably has a fairly late flight season this far north (Abbott, 2012). With the exception of the above September date, my visits to the region thus far have only been during the month of July. Further investigations later in the season may find this species to be present at other streams in the southeast portion of the state.

Sympetrum rubicundulum (Ruby Meadowhawk): On 15 July 2011, Bob Martinka and I visited a few locations north of Forsyth in Rosebud County. While sampling an



Sympetrum rubicundulum (Ruby Meadowhawk), male. Shallow reservoir north of Forsyth, Rosebud Co., Montana. 26 July 2011 area near a shallow, marshy reservoir along Dry Creek, Bob captured an immature male *Sympetrum* and asked for my opinion as to its identification. Upon examination of the individual, I noticed immediately the orange color in the basal half of the wings, and after noting that it was not *S. semicinctum* (Band-winged Meadowhawk), I expressed my excitement to Bob that he may have just captured Montana's first Ruby Meadowhawk. A close look at the hamules reinforced my conclusions, and I set about photographing and collecting the specimen (OC# 330468).

While doing such, Bob captured another immature *Sympetrum*, also with orange colored wing bases, and this time a female. Knowing that *S. internum* (Cherry-faced Meadowhawk) females will often show color in the wings; I examined the subgenital plate and determined that it too was another Ruby Meadowhawk. Late in the day, and with many more stops scheduled during the trip, Bob and I departed the area.

On 26 July 2011, I returned to this same location and found quite a bit more meadowhawk activity than what was seen just 11 days prior. Despite the increased number of *Sympetrum* species in the area, I was only able to locate two *S. rubicundulum* specimens, one mature pair. Of the six *Sympetrum* species observed in the area on the 26th, *S. rubicundulum* was by far the least common.

As was the case with *Archilestes grandis*, this too was a species which was thought to possibly occur in Montana (Miller & Gustafson, 1996). This recent finding, coupled with the known range of the species, to the south and east of Rosebud County, indicate that *S. rubicundulum* should occur in at least a few other southeast counties (Abbott, 2012; Donnelly, 2004b).

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Intergeneric copulation between *Sympetrum obtrusum* and *Leucorrhinia hudsonica*

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On 6 August 2011, as part of an annual odonates weekend sponsored by the Tahoe Institute for Natural Science, we joined Don Harriman for a visit to Grass Lake in El Dorado County, California. There are two Grass Lakes in El Dorado County, but the one most familiar to odonate enthusiasts, and the one referred to here, is the one at Luther Pass along Highway 89. This Grass Lake is a small body of open water, surrounded by the largest *Sphagnum* bog in California. It is also a quaking bog with a number of boreal plants unusual in the Sierra Nevada and a diverse marshland that is inundated to various depths depending on the time of year and preceding winter snowpack. The 2010–2011 winter brought a very deep snowpack to the area, and at the time of our visit almost the entire meadow was still holding standing water of at least a few inches, unusual for August.

We arrived at approximately 10 AM, and found the vegetation at the parking area to be swarming with roosting teneral meadowhawks, primarily *Sympetrum pallipes* (Striped Meadowhawk) and to a lesser extent, *S. obtrusum* (White-faced Meadowhawk). Making our way into the higher marsh we soon noted many of the expected odonates, and after about three hours we relocated to the lower marsh, which holds more open water, but is also more exposed to the day's rising breezes. Across the two marshes we found good numbers of *Lestes disjunctus* and *dryas* (Northern and Emerald Spreadwings), several *Coenagrion resolutum* (Taiga Bluet), *Enallagma annexum/boreale* (Northern/Boreal Bluets), and both *Ischnura perparva* and *cervula* (Western and Pacific Forktails).

Dragonflies dominated our attention, however, and we were looking specifically for *Leucorrhinia*. Two different

Fig. 1. Male *Leucorrhinia hudsonica* (Hudsonian Whiteface).

sized *Aeshna* spp. (mosaic darners) were flying, but we were unable to determine which species. We noted many *Somatochlora semicircularis* (Mountain Emerald; including pairs in tandem or wheel), a few male *Leucorrhinia glacialis* (Crimson-ringed Whiteface), many dozens of *L. hudsonica* (Hudsonian Whiteface; including several pairs in tandem or wheel), a few young male *Sympetrum danae* (Black Meadowhawk), many hundreds (possibly thousands) of *S. obtrusum* (many dozens of pairs in tandem or wheel), a few *S. pallipes* on the vegetation along the edge of the meadow, at least one *Libellula pulchella* (Twelve-spotted Skimmer), and many *L. quadrimaculata* (Four-spotted Skimmer).

Over the course of the day, we made several observations regarding Hudsonian Whiteface that are worth noting. First, every female we saw was an andromorph or red form. Second, we each noted a few males with greatly reduced marking on the abdomen, typically only showing two conspicuous spots, on abdominal segments 6–7 (Fig. 1). Manolis (2003) warns of inconspicuous abdominal spotting in this species, and Johnson (2008) has found strongly reduced and even lacking abdominal spotting in this species in the Oregon Cascades. As Johnson (2008) pointed out, this poses a considerable identification problem in places where *Leucorrhinia proxima* (Belted Whiteface) might occur, as both species have a single row of cells between the radial sector and radial planate. Observers should anticipate the possibility of spotless Hudsonian Whitefaces in the Sierra Nevada and northern California, and any extralimital observations of Belted Whiteface in this region should include careful examination of abdominal appendages.

Our most interesting observation occurred in the lower marsh, beginning approximately 2:20 PM, when we stumbled across an odd-looking pair of dragonflies in wheel formation, perched on the vegetation. We immediately recognized that it was a male White-faced Meadowhawk with a red-form female Hudsonian Whiteface and spent the next 10 minutes attempting to photograph the pair (Fig. 2). Occasionally we would inadvertently disturb the pair and they would fly a few meters before resting on the vegetation again. After 10 minutes, they separated and flew off in different directions.

Heterospecific pairings among Odonata are not particularly rare. Corbet (1999) summarizes 175 male-female heterospecific connections among the Odonata, and Miller and Fincke (2004) provide details and references for 111 heterospecific matings for male North American and European damselflies. These reviews found that pairings across different genera, but within the same family, represented approximately 29–30% of all heterospecific pairings. However, actual copulation only was observed in approximately 28% of those pairings (Miller & Fincke 2004). This number may be slightly higher for Anisoptera,

Fig. 2. Male *Sympetrum obtrusum* (White-faced Meadowhawk) in copula with a red-form female *Leucorrhinia hudsonica* (Hudsonian Whiteface).

most commonly among calopterygids and libellulids (Utzeri & Belfiore, 1990; Corbet, 1999), but intergeneric copulation remains a rarely observed phenomenon, and prolonged copulation, especially so.

We have reviewed the literature and believe that this represents only the second documented report of *Sympetrum* pairing with *Leucorrhinia*, following Eda's (1980) report of attempted copulation between a male *Leucorrhinia dubia orientalis* and female *Sympetrum danae*. Interestingly, *Sympetrum* accounts for a full 38% of Corbet's (1999) records of heterospecific linkages among Anisoptera. This may be a simple probabilistic result of the very high densities that *Sympetrum* achieves, not uncommonly with large numbers of several species flying in the same habitats at the same time. Additionally, the prevalence of records for heterospecific pairings in some taxa may be the result of intensive study within those groups (e.g. Singer, 1990 for *Leucorrhinia*).

It is perhaps worth pointing out that the female of this pair was an andromorph. Johnson (1975) hypothesized that female polymorphism was a mechanism of reproductive isolation, and that andromorph females were less likely to attract the sexual advances of males of other species. However, with two species as visually distinct as these two, this likely had little bearing on this mismatch. We would also like to point out that this observation was made in the afternoon, when Miller and Fincke (2004) found male *Enallagma* were less likely to make such mistakes, apparently due to a more even operational sex ratio.

We would like to thank to K. Biggs, J. Johnson, T. Manolis, D. Paulson, and K. Tennessen for their helpful discussion and encouragement with this note.

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Celithemis elisa (Calico Pennant) Point Count Continues—Season 7

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Summer 2011 marked the seventh consecutive season of our monitoring *Celithemis elisa* (Calico Pennant), and the species continues to amaze us with the phenomenal numbers that emerge from our simple farm pond. Over these seven years we have counted well over 32,000 tenerals and would like to think we are getting a handle on the behavior of this species, but they continue to surprise us.

Rain or shine we circle the pond every day between 0800 and 1000, their peak emergence hours. Although they continue to emerge throughout the day we count only the one time, knowing the end result will be a much higher number than what we report.

Thus far we have learned that the larvae leave the water in a great surge at the beginning of the emergence period regardless of weather conditions. Rain, heat, cold, wind, drought... ...nothing stops them. The first surge typically falls in the first or second week of June and lasts about five days. Numbers plummet for the rest of the season but are then consistent except in occasional minor surges.

Table 1. Summary of *Celithemis elisa* (Calico Pennant) emergence over seven seasons. Never think you have these things figured out. Just when it started to look like the phenomenal emergence was beginning to settle down, voila!

Year	Season Total	Peak Period	Peak Percent of Total	Total Emergence Period
2005	2,455	7–11 June	83% (2,028)	>62 Days
2006	10,944	5–9 June	47% (5,169)	63 Days
2007	6,497	1–6 June	75% (4,892)	61 Days
2008	8,237	8–12 June	76% (6,244)	64 Days
2009	1,505	6–10 June	15% (229)	68 Days
2010	642	31 May–4 June	43% (277)	82 Days
2011	1993	1 June–7 June	58% (1,152)	51 Days

Data sometimes seem to play tricks on long term monitoring projects. For instance, every season the first surge amounts to a very large percentage of the final total, anywhere from 43% to 83%; except in 2009 when the percentage was very low (15%). We have no explanation.

Most years we have observed thousands throughout the emergence period. Not in 2010, when the warm weather gave them a longer emergence period, but the numbers were at an all time low. No explanation there either, but we are glad we did not base a study on the data gathered from only that one season.

Because of their strict adherence to their circadian rhythm in early June, weather does not appear to be a factor in any of our observations, so we strive on. Besides focusing on the impressive primary surge of emergence we are also watching the smaller surges that pop up now and then throughout the season. A very intriguing behavior technique they exhibit is to emerge in clusters around the pond, as if the eggs of a single batch all stayed together throughout the entire larval life cycle.

While doing the counts we are privileged to observe behavior by other pond inhabitants as well. This year a Red-winged Blackbird discovered the bounty held within thick clumps of vegetation and enjoyed crashing around in the dense sedges, flushing and snapping up tenerals. He spent so much time patrolling and stuffing himself that he eventually left a flattened trail! Not to mention throwing off our counts by eating the data points.

Previous season recaps can be found in:

Gregoire, S. and J., 2007. *Celithemis elisa* (Calico Pennant) Emergence Period in the Fingerlakes Highlands of New York State. ARGIA 19(1): 10–11.

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Splash-Dunking Gone Bad: The Sticking Frequency

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There are many aspects of the recently described splash-dunk/spin-dry behavior in dragonflies (Walker, 2011) that are of interest. In this paper I concentrate on what happens when splash-dunking goes awry and a dragonfly gets stuck in the water. To put this phenomenon in context, I start with a brief overview of some of the general features of splash-dunking and spin-drying.

The Frequency of Splash-Dunking

Splash-dunking is a fairly common event at Cranberry Lake in Anacortes, Washington, where my wife Betsy and I do most of our observing. Though the rate of splash-dunking varies from day to day, as one might expect, on a typical day a splash-dunk event is observed every 5 to 10 minutes.

Figure 1 shows data recorded at Cranberry Lake during the 2011 dragonfly season. The upper set of data points shows the clear decrease in temperature during the season. The lower set of data points show the splash-dunk rate in dunks per hour. The average dunk rate is 6 dunks per hour, and the maximum rate is 12 dunks per hour. Though the temperature drops about 20° F during the observation period, the average dunk rate is essentially unchanged.

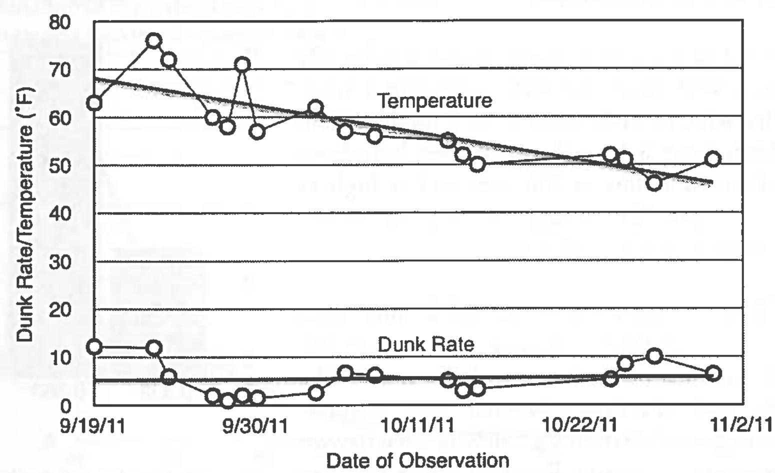

Figure 1. Temperature (upper data) and dunk rate (lower data) versus date of observation. The straight lines show the trends in the data; namely, a clear decrease for the temperature and no significant change for the dunk rate.

The Dragon Splash

When people see one of my slow-motion videos of darners slamming into the water during a splash-dunk (Walker, YouTube), they invariably remark on the intensity of the splash, and wonder how the wings survive such an impact. The fact that the wings hit the water with some force is illustrated by the shape and size of the splash that is produced.

Figure 2 shows a head-on view of a splash produced by a splash-dunking darner. The darners flying when this picture was taken were primarily Paddle-tailed Darners (*Aeshna palmata*), though a few Shadow Darners (*A. umbrosa*) were seen as well. When viewed from this angle the shape and symmetry of the splash becomes apparent. The image shown here is a frame capture from a slow-motion video, and hence of low resolution. Still, it shows the key features of what I like to call the "dragon splash." Notice the tri-lobed structure of the dragon splash, with a central component produced by the impact of the body, and symmetric side splashes from the wings impacting the water.

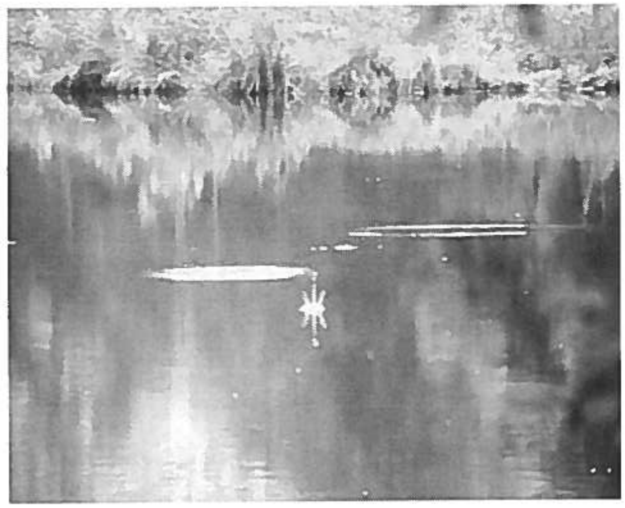

Figure 2. The tri-lobed "dragon splash" produced by a darner impacting the water. Dragonflies typically splash-dunk 1 to 6 times in succession, each time producing an impressive splash.

Dunk Time

When darners perform a splash-dunk, they don't dilly-dally in the water. They generally pop right back out in less than half a second. The number of dunks observed for a variety of time intervals is shown in Figure 3. The bar labeled "0.325" corresponds to times between 0.325 s and 0.349 s, the bar labeled "0.350" corresponds to times between 0.350 s and 0.374 s, and so on for the other bars. The average time it takes for a dragonfly to emerge from the water after a splash-dunk is 0.383 s.

Spin-Dry Parameters

After doing 1 to 6 splash-dunks, a dragonfly rises well above the water and does a spin-dry, which usually consists of 5 rotations and lasts about 0.44 s. Rotation rates have been observed as low as 760 rpm and as high as 1,600 rpm. The average rotation rate for our observations is 1,014 rpm.

There's a good reason extended spins with many more than 5 rotations are not observed. A complex object in three dimensions—like the body of a dragonfly—has three independent axes of rotation, each of which has its own moment of inertia. Rotation about the axes with the maximum and minimum moments of inertia is stable, but rotation about the axis with the intermediate moment of inertia is not stable. In the case of a dragonfly, the axis of rotation through the wings—which is the axis of the spin-dry motion—is the one with the intermediate moment of inertia. As a result, the spin-dry motion is inherently unstable. In fact, dragonflies pulling out of their spin-dry are often observed to be "wobbling" as they complete their last spin, a sign that the instability is affecting their rotation.

When Splash-Dunking Goes Wrong

Life doesn't always work out as planned. For splash-dunking dragonflies, this means that sometimes they don't make it back out of the water. If they can't become airborne again in half a second or less, they just aren't going to make it at all. The result is generally death by drowning, though predation may play a small role as well.

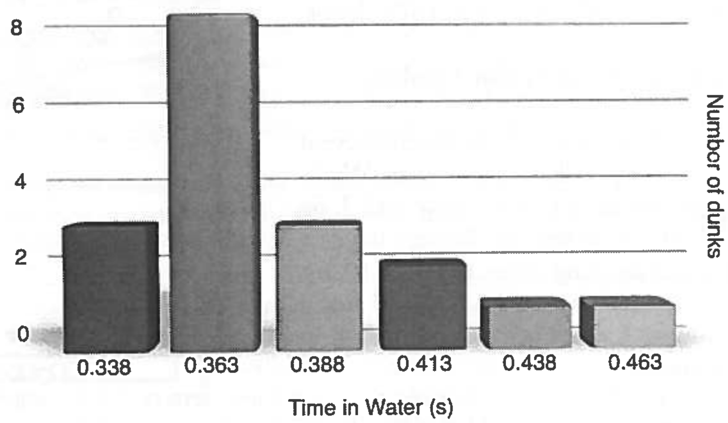

Figure 3. Number of dunks versus time spent in the water. The first bar is for times from 0.325 s to 0.349 s, the second bar for times between 0.350 s and 0.374 s, and so on.

Figure 4 shows a male Paddle-tailed Darner (*A. palmata*) that hit the water about 50 yards from shore and promptly became stuck. We refer to this as a "sticking event." All sticking events we observed occurred on the first splash-dunk, all happened with air temperatures below 65° F, and all were irreversible.

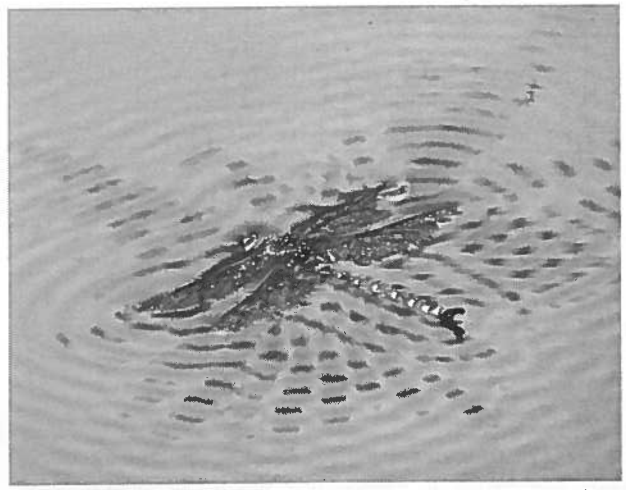

Figure 4. A male Paddle-tailed Darner (*A. palmata*) struggling to escape the water after a splash-dunk that didn't go well. At this point the darner is close to shore, after struggling for several minutes, and its wing beats are weak. Just after getting stuck its struggles were much more vigorous, several times getting the dragonfly to the verge of escape.

It's difficult to watch these gutsy animals struggling to free themselves from the water after getting stuck. They try so hard, come so close to escaping, and continue to struggle for such a long time. The individual shown in Figure 4 struggled for several minutes until—surprisingly—it "paddled" its way to shore right in front of me. I took the opportunity to rescue it and place it on a bush in the sun. After several minutes of drying out it took wing, apparently no worse for wear. I couldn't help wondering if it would splash-dunk again.

We observed the first sticking event on 19 September 2011, after having observed 90 successful splash-dunks starting back on the 4th of July. As the season progressed, and the temperature dropped, the sticking frequency increased to higher and higher levels. At the end of the season, when the temperature had dropped into the upper 40s, the sticking frequency was a full 25%—one in four splash-dunks resulted in death. The close inverse correlation between temperature and sticking frequency is shown in Figure 5.

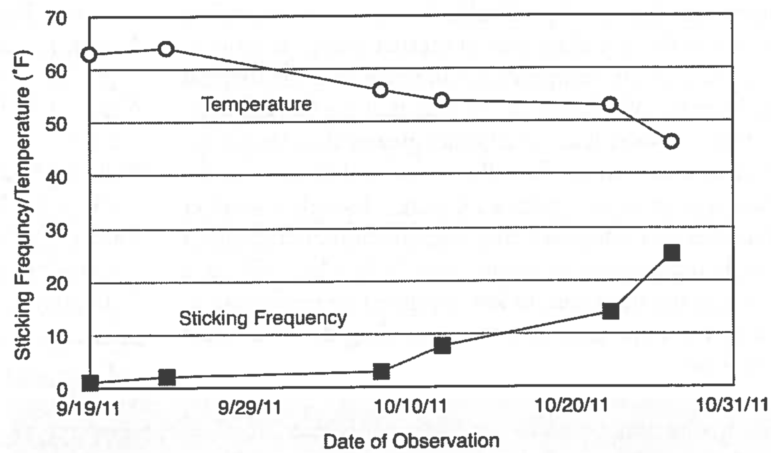

Figure 5. Temperature (upper data) and sticking frequency (lower data) as a function of the date of observation. The inverse correlation between temperature and sticking frequency is evident.

The same kind of behavior was seen in the fall of 2010, before we started collecting data. I remember going to Cranberry Lake one day in late October 2010 when the temperature was below 50° F. I would say as many as 10 darners were stuck in the water and trying to escape at any one time. It was depressing to see them struggling, knowing their efforts were futile.

In Figure 6 we plot sticking frequency as a function of temperature. Notice the nice fit to an exponential decay with increasing temperature. Another way to state this is that as temperature is decreased, the rate of increase in the sticking frequency is roughly proportional to the value of the sticking frequency. In this sense, the sharp rise in sticking frequency seen in Figure 5 is an indication of the dragonflies "hitting the wall" when it comes to their low-temperature flight capabilities.

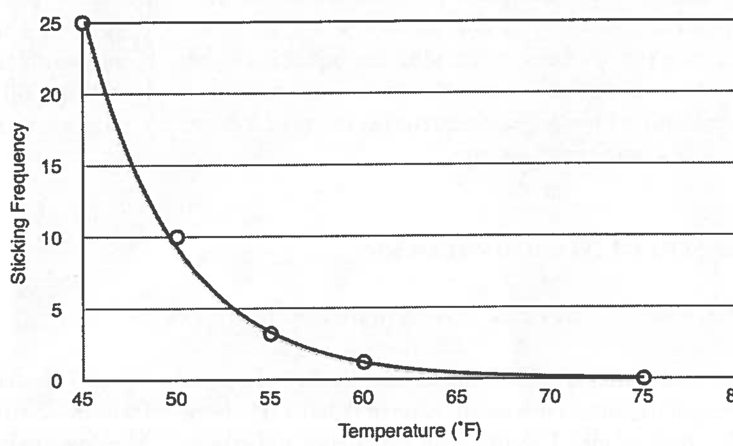

Figure 6. Sticking frequency as a function of temperature. The drop-off with increasing temperature is roughly exponential.

Minimum Flight Temperature

Our observations at Cranberry Lake show that dragonflies like the Paddle-tailed Darner (*A. palmata*) can fly at ambient temperatures as low as 44° F. This is in sharp contrast to a minimum flight temperature of 57.2° F reported for aeshnids (including *A. palmata*) in Alaska (Sformo & Doak, 2006). In any case, it's clear that flight at such low temperatures is pushing the envelope when it comes to a dragonfly maintaining the elevated thoracic temperature necessary for the flight muscles to operate efficiently. Sformo and Doak report thoracic operating temperatures in *A. palmata* of about 97° F.

It's difficult enough for a dragonfly to maintain the necessary high thoracic temperature when the surrounding air temperature is below 50° F, but the situation becomes much worse when the dragonfly splash-dunks into water. Even though the water temperature was the same as the air temperature at Cranberry Lake (within ±1° F), water drains thermal energy away from a dragonfly at a much higher rate than air. Specifically, Newton's law of cooling states that the rate of transfer of thermal energy is proportional to both the temperature difference and the thermal conductivity (Walker, 2010). Noting that the thermal conductivity of water is about 23 times greater than that of air, it's clear that a dragonfly will lose thermal energy rapidly when it is in contact with cool water. Though a number of studies have addressed thermoregulation in dragonflies at high-temperature extremes (May, 1976; May, 1995), less attention has been paid to low-temperature performance, and so far none seem to consider cooling due to contact with water.

Finally, one might wonder whether the increase in sticking frequency with decreasing temperature could be caused by an increase in the surface tension of water, making it harder for the dragonfly to escape (Kuntz, 2012). While this may be a contributing factor, the surface tension increases uniformly by only about 2% over the same temperature range where the sticking frequency increases sharply by over 20%. It seems the most important factor determining the sticking frequency is maintaining the thorax at operating temperature.

Summary

The sticking frequency of splash-dunking dragonflies shows a strong inverse correlation to ambient temperature. In fact, dragonflies engaging in the splash-dunk/spin-dry behavior when temperatures are less than 50° F are at significant risk of becoming stuck in the water—which is lethal.

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Walker, J.S. Slow-motion videos of splash-dunking and spin-drying can be found on the YouTube channel thedragonflyguy.

Request for *Orthemis* Specimens

Jerrell J. Daigle <jdaigle@nettally.com>

I am looking for specimens of the following *Orthemis* species: *O. ambirufa*, *O. anthracina*, *O. harpago*, *O. coracina*, and *O. regalis*, for DNA work. If you have any specimens to loan, I would really appreciate it. The specimens have to be less than 10 years old and only one leg will be taken. Let me know if you have any questions. Thank you very much!

A Swarm of Meadowhawks

James S. Walker, Anacortes, Washington <jswphys@aol.com>

When I read Dennis Paulson's interesting account of a mass gathering of baskettails in a recent issue of ARGIA (Paulson, 2011a), I had no idea I would soon experience something similar—though on a much smaller scale. After the experience I describe below, I read another article by Dennis Paulson (2011b) describing a mass gathering of Striped Meadowhawks (*Sympetrum pallipes*). There seems to be "something in the air" when it comes to events like these.

In my case, the dragonflies involved were Autumn Meadowhawks (*S. vicinum*). These friendly dragonflies like to land on people, as shown in Figure 1.

Autumn Meadowhawks are a common sight at Cranberry Lake in Anacortes, Washington late in the season. They are well described by a famous haiku:

> Red dragonfly on my shoulder,
> Calls me his friend.
> Autumn has arrived.

I've often had them "on my shoulder," but last autumn I had them covering my entire body—literally from head to toe. Here's what happened.

I went to Cranberry Lake on 9 November 2011 to observe the dragonfly activity. The weather was sunny and calm, with an air temperature of 57° F. On other similar days I would observe about a dozen Autumn Meadowhawks and half a dozen Shadow Darners (*Aeshna umbrosa*). On this day, however, I immediately realized something was different—there were so many Autumn Meadowhawks on the gravel walking path that I had to choose my steps carefully to keep from stepping on any of them.

I walked to some bushes near the shore to see if any darners were perched there, but as soon as I stood still for a moment the meadowhawks began to gather on me. It felt like a scene from Hitchcock's movie, The Birds. They were landing all over me in a frenzy. I took some pictures showing the ones perched from my waist down, as in Figure 2, but as I took those pictures I could feel them perched on my arms, my upper body, my head, even on my face. The pictures show over 30 on my lower body, and I would estimate there were 50 or more on my body as a whole. I've had several Autumn Meadowhawks land on me before, but never anything like this.

After taking a few pictures I looked up and saw that the air was "full" of them flying in all directions, hooking up in tandem or attempting to hook up. It was similar to a mass flight of winged ants or termites. A few darners were flying too, picking off individual meadowhawks, and also pairs in tandem, and heading for the bushes or trees to enjoy their catch. It was quite a scene. It's hard to estimate the number of meadowhawks, but it must have been in the several hundreds.

I decided to go home and bring my wife Betsy to see this phenomenon. As I walked back to the car the meadowhawks went along for the ride on my body. The car was a considerable distance away, and in the shade, but there were still a dozen or more dragonflies on me when I got there. I had to "shoo" them away to keep them from getting into the car with me—though one managed to do so anyway.

Figure 1. My wife Betsy Walker experiences a red dragonfly on the shoulder, and a second one on her hat. Both are male Autumn Meadowhawks (*S. vicinum*), the friendliest dragonfly we know.

When Betsy and I returned a few minutes later, the activity level was a bit lower, though still intense. We marveled at the meadowhawks that seemed to be everywhere we looked, including all over us. Along the shore we observed an egg-laying frenzy, with intense competition for prime

Figure 2. A gathering of Autumn Meadowhawks (*S. vicinum*) at Cranberry Lake in Anacortes, Wa on 9 November 2011. The ones pictured on my lower body are only half the story—they covered me from head to toe.

sites. As a result of the competition, many meadowhawks were getting knocked into the water where they became stuck. We ended up rescuing a dozen or more.

As we watched the egg-laying activity, the shadows of the afternoon (it was about 2:00 PM at this point) began to lengthen. We expected to see the meadowhawks moving along the shore to stay in the sunlit areas, but at one point—quite suddenly—we noticed that the egg laying had ceased, and the air was now clear of meadowhawks. It was almost as if someone had flipped a switch. We're not sure what the signal for stopping activity was—it wasn't evident to us—but the meadowhawks seemed to respond en masse.

We returned the next several days, but each time the activity was completely normal again, with just a dozen or so meadowhawks along the shore. The mass behavior seen on 9 November was a short-lived phenomenon, but one we're happy to have experienced.

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Paulson, D. 2011b. Would you believe a million meadowhawks? ARGIA 23(4): 24–26.

2012 Nick and Ailsa Donnelly Fellowship Awarded

Fredy Palacino has been awarded a Nick and Ailsa Donnelly Fellowship to attend the 2012 DSA annual meeting in Florence, South Carolina. Congratulations Fredy!

A Student in the Making?

Ken Tennessen <ktennessen@centurytel.net>

My five-year-old granddaughter came into my study early Christmas Eve morning. I was peering through my microscope, thinking I could finish drawing the secondary genitalia of a *Micrathyria* male that didn't quite fit the species I initially thought it was, this in the quiet time before anyone else got up (typically I draw when I need to compare details of species in question). Pink blanket in hand, she piped up, "Papa Ken, what are you drawing?" [I wanted to be "Grandfather" but have come to accept her pet name for me]. Taken by surprise, I turned and whispered "Good Morning. I'm drawing a small part of a dragonfly that will help me figure out what species it is." Of course, she wanted to see, so I slid my paper in front of her. "That's not very good, Papa Ken."

I picked up my plain pen and ink drawing, my critic too, and went over to the computer. I scanned the drawing then bundled her up in "Pinky" before zooming in on the finished part of the drawing—the hamule and anterior lamina. Our conversation then went something like this:

"See those small dark teeth on the tip of the hamule?" I asked.

She nodded. "Uh huh. But what colors are those parts?"

"Mostly tan, but darker around the edges."

"Kind of brown?"

"Yes, light brown. Around the edge."

"Can I draw them?"

She slid off my lap. I gave her a piece of blank paper and pencil. She stood by my desk, tippy-toed, little bare feet on the cold hardwood floor. Within a minute she'd rendered quite closely the shapes on the computer screen. "This is how it should look," she asserted, then headed downstairs for her box of crayons. Obediently I followed. A few minutes later it was done (see figure below). And I saw a detail I hadn't noticed before—the hamule did not surpass the anterior lamina.

Some of you might be wondering, as did I when I started, why write this little story for the pages of ARGIA? I have this to offer. First of all, if you really want to see something, draw and compare. And, I think there are times that we