The inadequacy of passive, wind-driven traps in assessing the aerial insects of Delta Marsh

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Introduction

Wetlands are areas of tremendous biotic productivity and the insect assemblage of Delta Marsh is a good example of this generality. Immense aerial masses of such insects as the Chironomidae and Culicidae often turn the skies above the marsh as black as smoke. Such abundance is indicative of the insects' important role in the marsh food web. While insects are significant as herbivores, carnivores and parasites, it is perhaps their role as a food resource that has garnered them the most attention. The insects are particularly important as food for the numerous songbirds and waterfowl of the Delta Marsh region.

I conducted a study over the summer of 1996 in an attempt to quantify the diversity and abundance of the aerial insects, with emphasis on the numerous and ubiquitous chironomids, of the marsh. The rationale for the study was that it would provide information that could prove useful in subsequently describing the food web of Delta Marsh. However, the study was only moderately successful because, simply stated, the sampling protocol was inadequate in assessing the aerial insect community for reasons that I will discuss. My primary intent, therefore, is to describe and critique the method used in 1996 then suggest a sampling protocol that would more accurately represent the aerial insects of Delta Marsh. The focus shall be on the chironomids but other pestilent nematocerous dipterans will also be discussed.

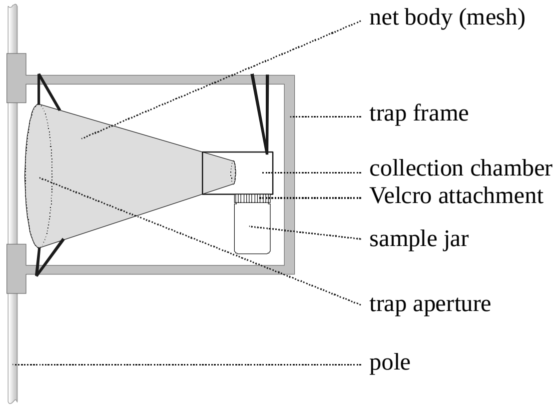

Figure 1. Pivoting, wind-orientated trap used to sample aerial insects in 1996.

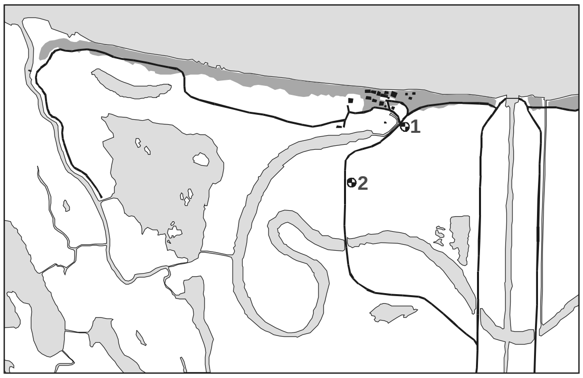

Figure 2. Location of two sites along the "winter road" where aerial insect traps were deployed in 1996.

Materials and Methods

In early spring, before any significant insect emergence, two wind-orientated stationary nets (Fig. 1) were placed at two sites along the winter road at field station. These traps were fastened to a pole about 1.5 m above the ground, and pivoted about this pole so as to always face into the wind. Trap 1 was placed at the intersection of the winter road and the road to the PCC property. Trap 2 was situated about halfway between Trap 1 and the point at which the road crossed Blind Channel (Fig. 2). The nets remained at these sites for the entire sampling period except when taken down briefly for maintenance.

Insect samples were collected daily from each trap from 26 May to 22 August 1996. The traps were opened (by removing a screen that covered the trap aperture) at approximately 6:30 every morning. Between this time and 8:00 in the evening, the traps would collect insects driven by the wind. Theoretically, the insects would be forced by the wind into the collection chamber. Unable

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to escape, the insects would eventually fall into the collection jar containing a preservative (70% ethanol). The traps were closed by placing a screen over the trap opening. The day's collection was then transferred to a sample bag to be processed at a later date. Fourteen samples were processed per week. All insects in a sample were sorted to Family and counted.

Results

Most aerial arthropod Families, including all those in the Orders Ephemeroptera, Odonata, Hemiptera, Homoptera, Trichoptera and lepidoptera, were present in negligible quantities in all samples. Often Families in these Orders were only represented by a few specimens throughout the summer. For example, the Odonata were represented by a couple of simultaneously captured coenagrionid damselflies. Parasitic Hymenoptera were only slightly better represented in the samples. The majority of samples consisted of insects of the Orders Coleoptera and Diptera. The beetles were predominantly staphylinids. The Diptera were easily the most abundant and diverse insects caught in the traps. Nematocerous flies were primarily represented, with relatively large numbers of culicids, psychodids and simuliids. However, the flies of the Chironomidae were the prime components of all samples, by far the most important in terms of diversity, abundance and biomass (Figs. 3,4).

Discussion

I contend that these results are not indicative of the true richness and abundance of aerial insects that occur in Delta Marsh because the sampling protocol used here was inappropriate. On calm days, aerial insects could quite simply avoid or escape the traps as their flight speed was in excess of the wind speed. Those insects found in the traps on such still days were purely incidental. As wind velocity increased and exceeded an insect's flight speed, it effectively became an inanimate object and was at the mercy of the wind. So, strong flying, robust insects would be more likely to avoid the traps at a given wind speed than a more delicate fly (Service 1976). *Chironomus*, the abundant large midge which forms Delta Marsh's characteristic mating swarms, illustrates this point. It was visibly one of the dominant aerial insects in the summer of 1996 but this perception was not supported by the sampling results. *Chironomus* is a strong enough flier to have avoided the traps at the low to moderate wind speeds, only being significantly represented in the sample during strong winds. Stronger flying insects of larger size could avoid the traps under most any wind speed. The large dragonflies *Aeshna* and *Libellula* were present in large numbers in the marsh. However, they were never collected in any sample, simply because they are effective fliers. The wind was never sufficiently strong to push them into the traps.

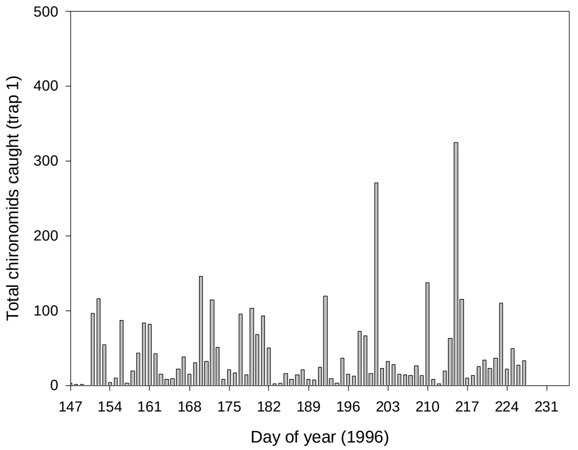

Figure 3. Total chironomids (small, medium, large) caught in Trap 1 in 1996. Day 147 = 26 May; Day 234 = 22 August.

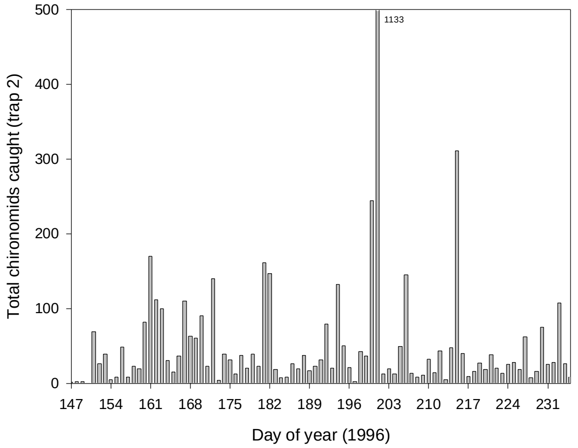

Figure 4. Total chironomids (small, medium, large) caught in Trap 2 in 1996. Day 147 = 26 May; Day 234 = 22 August.

A second reason that the sampling procedure was inadequate was that the traps sampled different volumes of air depending on the velocity of the wind entering the trap aperture. Generally, the higher the wind velocity, the higher the volume of air sampled, and consequently the more insects theoretically sampled. Furthermore, the surface area (terrain) that would be effectively sampled increased in direct proportion to wind velocity. In other words, stronger winds would be more likely to bring insects from further away within the vicinity of the trap. The result is that the collected sample probably consisted of insects from the surrounding wetlands on a calm day but insects from the surrounding agricultural fields would also be sampled on a very windy day.

While flying insects may be more susceptible to these pivoting traps at high wind speeds, far fewer insects are actively flying as the wind becomes more forceful. Most insects seek shelter as the wind picks up, and thus remain protected from the wind until calmer conditions arise. So, as the wind speed increases, the fewer flying insects there are in the air.

At extremely high wind speeds, another problem with the sampling equipment becomes evident. A point is reached on very windy days where the mesh size of the net is too small to allow the entire volume of air entering to pass through. Effectively, the input volume of air into the net aperture begins to exceed the output through the mesh. To compensate, air in the net begins to be forced out through the net aperture. This is the phenomenon of backflow, which can become so serious as to reduce the effective volume of air passing through the trap to negligible levels. Insects entering the net are basically pushed back out by the countercurrent generated by backflow.

The sampling results from my study are inaccurate in assessing the abundance and diversity of the aerial insect community at Delta Marsh because no mechanism for measuring wind velocity in the trap apertures was available. The data cannot be then standardized against volume, and so are basically incomparable. Standardizing the data against the field station’s meteorological station wind velocity records would probably improve the results, but still would be highly inaccurate. This is due to the fact that the volume of air passing through the net aperture is less than would pass through the same area without a net (Holzapfel and Harrell in Service 1976). Consequently, the wind’s speed decreases upon entering the net.

Solving the wind speed problem could be dealt with in at least two ways. Initially, an instrument (such as an anemometer) to measure windspeed could be placed in the trap aperture. The volume of air passing through the net during each daily sampling period could then be recorded, and all samples could be standardized against air volume. Conversely, a mathematical relationship between the meteorological station’s wind speeds and the net aperture’s wind speeds could be worked out. Subsequently, mean wind speeds for each daily sampling period could be read from the meteorological station data, and then converted into the equivalent net aperture wind speeds. Whichever method is used, the sampling data must be standardized for air volume to be in any way useful.

Another problem with the sampling protocol followed during the summer of 1996 was its failure to account for the diel patterns of emergence and peak activity exhibited by the chironomids and other nematocerous insects. In most cases, these aerial adult insects emerge from their aquatic pupae within a restricted time period due to the effect of some prior synchronizing effect (usually temperature) (Corbet 1964). The result is peak emergence periods, wherein most of a population exits the water and enters the atmosphere. Not uncommonly, these peak emergence periods occurred during the early hours of the morning and late in the evening. The traps were opened at 6:30 a.m. and closed at 8:00 p.m. So, these large emergences of insects would certainly not be recorded, resulting in an underestimation of the abundance of aerial insects in the marsh. *Chironomus plumosus*, for example, exhibits diel periodicity in its emergence pattern. This population’s peak emergence begins approximately one hour before sunset, and then continues well into the night (Hilsenhoff 1966). However, the sampling nets were closed just as this emergence would begin. A similar problem occurred with the culicids. These have peak emergence periods very early in the morning (4:00 a.m.) and then again the late evening (Barnard and Mulla 1977).

It is arguable that insects emerging in the night hours (between 8:00 p.m. and 6:30 a.m.) are still readily available for sampling during the next open trap period. To a certain extent this is true; insects emerging at night can still form a portion of the following day’s sample. However, these emerging insects exhibit peak activity (flight) periods in the late evening. They are typically less apt to fly in the daytime, and so cannot be sampled by wind-driven aerial traps. Relying on daytime samples only surely creates underestimates of the true insect abundance. For it is in the late evening that the phenomenon of mating swarms occurs, where virtually every insect of a swarming population is actively flying, and thus is available for sampling with wind-driven traps.

Anyone who has spent time at the field station during one of the major chironomid emergences will be familiar with swarming behaviour. In the late evening (and to lesser extent at sunrise), large masses of males, some with millions of individuals, form in relation to some conspicuous element of the landscape (Downes 1969, Hilsenhoff 1966). At Delta Marsh, the *Chironomus* swarms seem to locate themselves above such landmarks as the summer road, the beach or even a conspicuous tree. These swarms remain a relatively constant distance from the swarm marker, adjusting height and position with changing wind conditions. Chironomid swarms are characteristically columnar in form, as exemplified by the *Chironomus* at Delta Marsh (Syrjamaki 1964). Females engage the mating process by entering the swarms from their resting places on the adjacent vegetation. After successfully mating, the females quickly leave the swarms and alight on vegetation. So, while the female composition of a swarm at any one time may be quite small (5% of the chironomids in a swarm), most females in the vicinity will at one point enter the swarm. A chironomid swarm is an effective aggregation of the majority of the individuals composing the population.

Simply leaving the wind-driven traps open during the night hours is not adequate for sampling these swarming insects. Initially, the times when these swarms form (dawn and dusk) are also typically the times of lowest wind velocity. Females tend to spend the majority of their time resting in the vegetation. Finally, when the males form these large contiguous masses, and tend not to stray too far unless otherwise stimulated. Whereas most of the chironomid population is within the vicinity of the swarms, their swarming behaviour is not conducive to passive trapping. Some sort of active trapping technique would seem to be the best choice for sampling the night swarming populations of insects at the Delta Marsh.

Actively light-trapping night flying swarming insects would perhaps be the ideal solution to this problem. Insects are generally positively phototactic to a point light source. Such a trap would then attract both male and female components of a swarming insect population. The light trap would have to include a fan to draw in the light bodied insects, such as midges or mosquitoes, which are attracted to the light source. Such light-bodied insects may simply fly around the light and not enter the trap, or may even demonstrate negative phototaxis when very close to the light source (Service 1976). The New Jersey light trap is commonly used for sampling swarming nematocerous insects, and perhaps could be used here as well. However, this is only one suggestion from a multitude of available designs in the light trap domain. Active trapping with light could occur during those same hours that the wind-driven passive nets were closed. This light-trapping would hardly be labour intensive. One need only turn on the light source in the evening, and shut it off in the morning while collecting the sample jar.

The wind-driven traps used during the summer of 1996 had another failing, allowing for a substantial underestimate of the culicids. If one were simply to examine Figs. 5 and 6, the conclusion would be that mosquitoes are not prevalent at Delta Marsh. However, anyone spending any amount of time in the marsh environs during the summer months would very quickly reach a very different conclusion. Mosquitoes are very common, perhaps second only in importance to the chironomids. They can occur in such numbers as to render their nuisance factor very quickly unbearable.

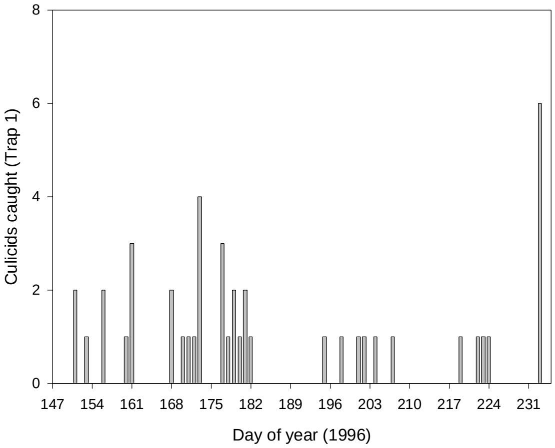

Figure 5. Culicids caught in Trap 1 in 1996. Day 147 = 26 May; Day 234 = 22 August.

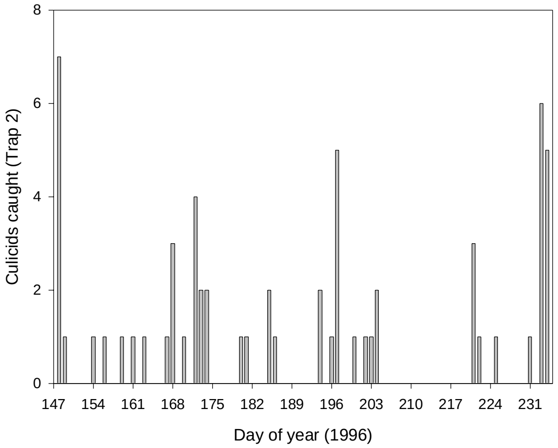

Figure 6. Culicids caught in Trap 2 in 1996. Day 147 = 26 May; Day 234 = 22 August.

The reason that the culicids are so poorly represented in the sampling record of the summer of 1996 is that they only actively take to the air when disturbed. Service (1976) states that mosquitoes spend more time in a state of rest, protected by some sort of shelter (i.e. vegetation). Upon disturbance, a swarm of predominantly unfed females forms about the potential blood meal donor, whereas males and blood-fed/gravid females only begin actively flying if actually dislodged from their resting site. This phenomenon was quite easily observed when the traps were either opened or closed. Whereas very few (if any) culicids would be found in the sample jar, a large swarm would form about the person servicing the trap, indicating that culicids in the vicinity of the trap were quite prevalent.

It would seem that to assess adequately the abundance of the culicids at the Delta Marsh, one would have to sample the resting community. The culicids at the marsh predominantly rest in the grasses and sedges which are dominant in the marsh, as well as in the foliage of bushes and shrubs on the beach ridge. A simple, effective way of sampling this resting population would be to use sturdy sweep nets. In order to make the data comparable, 27 long sweeps closely approximates a volume of 1 m3 sampled. Once a sample was collected, the net could simply be placed in a freezer, thus killing all insects contained within. The sample could then be easily sorted and counted. Throughout the summer months, randomly placed and timed samples could be taken, thus obtaining an adequate assessment of culicid abundance.

It was initially assumed that the wind-driven traps used here would provide reasonable data on the diversity and abundance of aerial insects at the field station. However, I conclude from the foregoing that this sampling regime was inadequate for obtaining accurate results. The sampling protocol failed because it did not account for wind speed (and thus volume sampled), diel periodicity of activity in aerial insects, and the phenomenon of resting in the culicids. This report has presented a few techniques (though many more exist) on how this sampling protocol could be improved. I hope that this information may prove useful in designing future monitoring studies of the diversity and abundance of aerial insects at Delta Marsh.

Acknowledgements

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