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GMCA Newsletter

Volume 12, Issue 1 **April 29, 2021**

The Importance of Logos

…and the winners are…

Annual Meeting Update

Athens, GA; 2021

We are planning to have our 2021 meeting in October in Athens, GA, and we will need speakers. We need speakers who are willing to talk about mosquitoes, mosquito research, mosquito control, or just about any topic related to mosquitoes. We also usually have one or two non-mosquito talks. Our shortest talks are ~15 minutes, but we are happy to listen to you for an hour if you have something interesting to say. We especially like to have a good mix of operational vs research talks and talks from commercial vs municipal applicators, so please consider coming to give a talk if you are an applicator or a student doing research. We are an easy group to talk to, so no worries.

We do have some limited funding to help speakers with hotel and registration costs, and to pay for one person to attend the meeting who couldn't otherwise. Given all that, please consider giving a talk at the GMCA meeting in 2021. We all love to hear new stories from the lab and field.

Inside This Issue

We are always looking for contributors to the GMCA Newsletter, so if you have an interesting story to tell about mosquitoes or mosquito control, please send it to rosmarie.kelly@dph.ga.gov.

Culex Capers
By Kristin Reichardt
Vector Surveillance Coordinator
Richmond County Mosquito Control

Richmond County Mosquito Control (RCMC) conducts routine adult mosquito surveillance using light and gravid mosquito traps. One of our light traps has consistently trapped more mosquitoes than the others in recent weeks. Concerningly, most of these mosquitoes at this site have been *Culex salinarius*, which vectors West Nile virus and Eastern Equine Encephalitis virus. So, in response to these trapping results, I visited the site on February 4, 2021, to see if I could pinpoint where these *Cx. salinarius* might be coming from.

The trapping site is in a large neighborhood in the southern part of Augusta, Georgia, where the county begins to transition from a commercial and urban/suburban landscape to more industrial and rural. There is a large stormwater ditch that runs through the neighborhood. Upon inspection, the water in the ditch was flowing, as we have had a wet winter/early spring, and I found no mosquito breeding. The day I inspected was cold, overcast, windy, and a little drizzly, so I decided to look for an area where adult mosquitoes might be sheltering. The two most plausible areas were the stormwater structures feeding water into and out of the ditch. I got my flashlight and made my way into one of the structures, and jackpot! Hundreds if not thousands of adult female mosquitoes were sheltering inside.

Given these findings, we decided to start setting a supplemental light and gravid trap closer to the structure (at the red star) to compare to our routine site (at the yellow star). I also returned to the structure on February 17, this time equipped with a partner, an aspirator, and plenty of collection vials. We collected hundreds of mosquitoes and brought them back to our office. After an unfortunately failed attempt to keep them alive and test them for insecticide resistance, I identified 200 individuals; 100% *Culex erraticus*! This species, like *Cx. salinarius*, is implicated in Eastern Equine Encephalitis virus transmission (For context, Richmond County had zero EEEV+ mosquito pools, equines, or humans reported in 2020, but neighboring Aiken County in South Carolina had at least 1 EEEV+ equine reported.)

Interestingly, even though so many adult *Cx. erraticus* were in the structure, we trapped no *Cx. erraticus* in *any* trap throughout our county from 11/17/2020 to 02/02/2021. The results from the supplemental traps we've set have been unexpected, too. For the first week of supplemental trapping, counts closer to the structure were indeed higher, but because of *Cx. salinarius*, not *Cx. erraticus* (see bar chart).

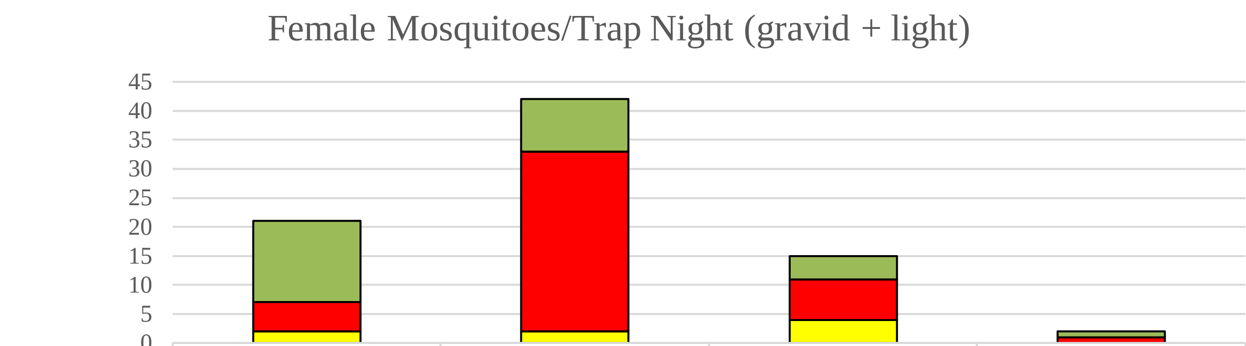
These findings from my *Culex* capers raise some interesting questions. How do the behavioral diapause patterns of *Cx. erraticus* differ from other *Culex* species (e.g., *Cx. salinarius*), especially in Georgia where winters are mild, with several days conducive to adult mosquito activity? In other words, why did we see *Cx. salinarius* in our host-seeking light traps when there was such a large density of *Culex erraticus* so close by? How do these two species, *Cx. erraticus* and *Cx. salinarius*, contribute to EEEV maintenance in Georgia early in the year? Are there any inter-species interactions at play? Which adult mosquito control measures could be employed to kill the mosquitoes in this unique environment where pollution of the stormwater is a concern? And where was the larval habitat that produced these mosquitoes?

For now, RCMC will continue to monitor this site for larval and adult mosquitoes in the hopes of better understanding the seasonal patterns of these two species. For more information about our surveillance efforts or to contribute any feedback or theories about these intriguing results, please feel free to email the RCMC Vector Surveillance Coordinator Kristin Reichardt at Kristin.Reichardt@dph.ga.gov.

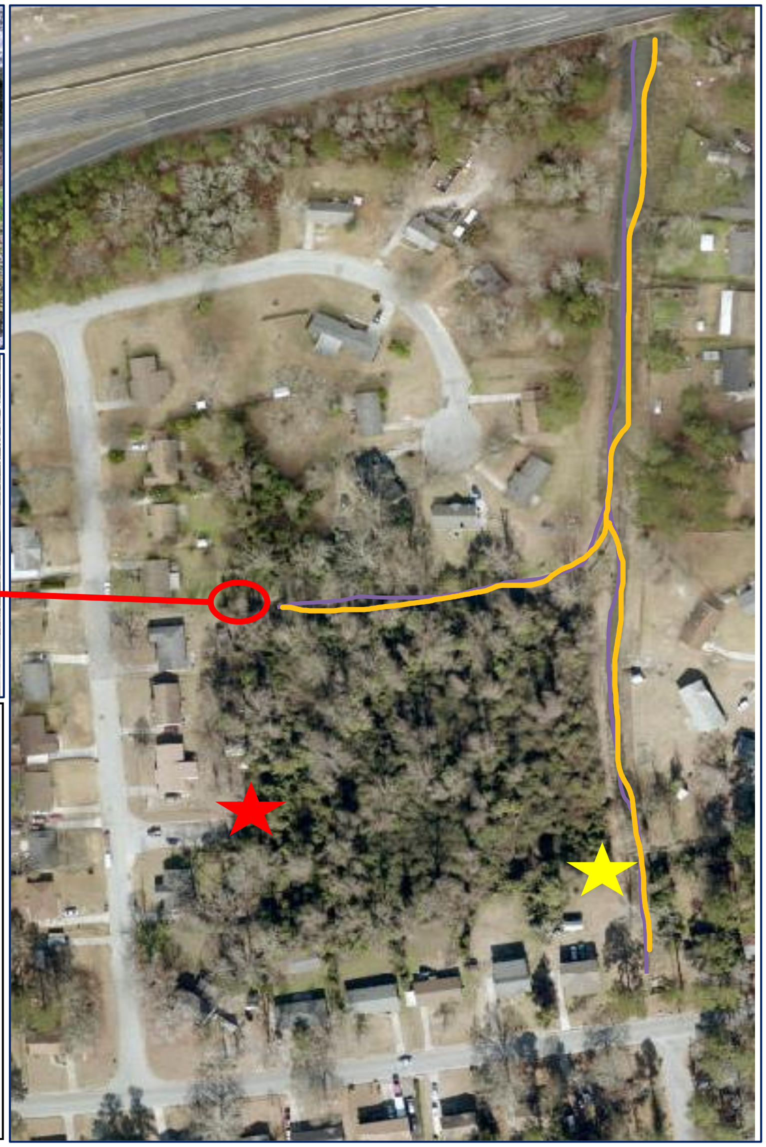
Cx salinarius

Cx erraticus

(continued on page 3)



	Routine 2/9	Supplemental 2/9	Routine 2/23	Supplemental 2/23
Other	14	9	4	1
Cx. salinarius	5	31	7	1
Cx. erraticus	2	2	4	



Top Left: The section of the creek leading up to the stormwater structure.
Bottom Left: The stormwater structure where I found *Culex erraticus*.
Right: An aerial GIS photo of the neighborhood. The stormwater ditch is highlighted in orange. The yellow star is our routine trapping site. The red star is the new supplemental site.

Georgia Surveillance Results, GDPH 2020

Even with a pandemic and the loss of funding that reduced our surveillance team at the State down to 2 from a total of 7, we managed to collect mosquito data from 142 of Georgia's 159 counties. We also had mosquitoes from 9 counties tested for arboviral diseases. Of course, we couldn't have done it with help of local and District environmental health and a number of mosquito control programs. Thanks to all who contributed.

Human arboviral cases were down in 2020, likely in part due to the understandable focus on Covid-19.

year	WNV Index	WNV+ Pools	human cases
2001	146.3	31	6
2002	106.6	57	37
2003	50.7	105	60
2004	40.7	126	24
2005	17.7	67	24
2006	31.5	81	10
2007	29.9	75	60
2008	25.3	50	12
2009	13.7	24	6
2010	47.7	99	14
2011	179.6	397	26
2012	64.3	125	117
2013	72.0	150	20
2014	43.6	56	13
2015	37.00	40	17
2016	22.80	36	13
2017	148.00	276	64
2018	202.30	310	38
2019	113.40	243	16
2020	24.60	59	12

We also managed a bit of tick surveillance in collaboration with the Georgia Department of Agriculture and the Georgia Department of Natural Resources. In October and November, we collected ticks of deer at 4 quota hunts at 2 different Wildlife Management Areas. We hope to continue and expand our tick work in 2021, as well as continuing mosquito surveillance. If you are interested in the annual mosquito summaries, they are posted at http://www.gamosquito.org/mosquito.htm. I can send you tick and arboviral summaries if you are interested. Just send me an email at Rosmarie.Kelly@dph.ga.gov.

Cedar Creek WMA

Species	females	larvae	males	nymphs	Grand Total
Amblyomma americanum					
10/15/20		200	2	23	225
10/16/20	3			3	6
11/12/20				1	1
11/13/20	1	1	2	1	5
Amblyomma maculatum					
11/13/20	1		2		3
Ixodes scapularis					
10/16/20	10		4		14
11/12/20	112		69		181
11/13/20	49		34		83
Grand Total	**176**	**201**	**113**	**28**	**518**

Clybel WMA

Species	females	males	nymphs	Grand Total
Amblyomma americanum				
11/5/20		1		1
11/6/20	1	1	2	4
Ixodes scapularis				
11/5/20	41	36		77
11/6/20	24	17		41
11/19/20	3	3		6
11/20/20	3	1		4
Grand Total	**72**	**59**	**2**	**133**

The Georgia Mosquito Control Association

GMCA
c/o Kristin Reichardt
Richmond County Public Health
Richmond County Mosquito Control
1916 North Leg Rd
Augusta, GA 30909

www.GAmosquito.org

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GMCA Newsletter Supplement

Volume 12, Issue 1s

Mosquito Control and the Monarch Butterfly in Georgia

The world of mosquito control tends to be in state of constant change as technology evolves and science expands. Making adjustments by implementing new technologies and incorporating the knowledge unveiled by science are key components to managing a successful Integrated Pest Management (IPM) mosquito control program. Some changes may be easily accomplished, such as timing an adulticide mission to better coincide with the activity of a particular mosquito species. Others may be much more involved, like moving to a completely new, real-time customer database. Some changes have nothing to do with the biological or operational ends of mosquito control, but more to do with the environmental or social aspects of control efforts, and how this work affects non-target organisms, or how the public views such work. An excellent example of this would be potential adverse effects of mosquito adulticide treatments on honeybee populations. With this in mind, it is important to keep an eye on things that may have an impact on mosquito control operations in the future.

Figure 1: Monarch Butterfly

In December of 2020, the U.S. Fish and Wildlife Service (USFWS) announced that listing the monarch butterfly (*Danaus plexippus*) as an endangered or threatened species under the Endangered Species Act (ESA) is warranted but precluded by higher priority listing actions. Because of this decision, the monarch becomes a candidate for listing, and its status reviewed each year. Currently, the USFWS rates imperiled species numerically, and the monarch has been graded a listing priority number of eight. This priority number indicates that the magnitude of threats to the monarch is moderate and that those threats are imminent (https://www.fws.gov/news/ShowNews.cfm?ref=u.s.-fish-and-wildlife-service-finds-endangered-species-act-listing-for-&_ID=36817). It is impossible to predict the ramifications of elevating the monarch butterfly from an unprotected species to a candidate for protection on mosquito control operations, however, it may be prudent for all mosquito abatement agencies to take a look at their programs and consider how to mitigate conflicts with a wide-ranging and free-flying species like the monarch.

In order to conduct such an evaluation, it is wise to first examine the biology of the monarch itself. The monarch is an iconic, brightly colored butterfly (Fig 1), well known for its annual migrations each autumn to areas in California (the western population) or Mexico and southern Florida (the eastern population). Seemingly, the two populations are separated by the Rocky Mountains, although, evidence for at least some interchange between these two populations exist (Pyle, 2015), and no significant genetic difference is found between butterflies from the western and eastern portions of North America (Lyons et al., 2012). Both North American populations originate from the northern zones of the United States and southern Canada, and their migration events have been well summarized by Brower (1995). The population occurring east of the Rocky Mountains may further be separated by the flyway paths used during the fall exodus, with a primary pathway west of the Appalachian Mountains and another to the east (Howard and Davis, 2009). In Mexico, large aggregations totaling millions of butterflies overwinter in high elevation conifer forests composed predominantly of oyamel fir, *Abies religiosa*, (Urquhart and Urquhart, 1976a). Such massive aggregations have not been reported in Florida, although anecdotal information exists of smaller aggregations of an acre in size or clusters and loose aggregations within larger tracts along the Gulf Coast of Florida (see Brower, 1995). However, unlike the overwintering population in Mexico which consists of reproductively inactive adults, some winter breeding in the southern states apparently occurs on at least a small scale (Knight and Brower, 2009; Howard et al., 2010; Satterfield et al., 2015).

Monarchs share a close similarity in appearance with the viceroy butterfly, *Limenitis archippus*, (Fig. 2) which represents a prime example of Müllerian mimicry. Originally, this resemblance was considered an example of Batesian mimicry, where predators avoid an edible animal (the viceroy) because of its likeness to a noxious or otherwise harmful animal (the monarch). However, work has shown that viceroys are as unpalatable as the monarch (Ritland and Brower, 1991), indicating that both species are noxious to the taste of predators, and share the burden of predator education as co-mimics.

Figure 2: Viceroy Butterfly

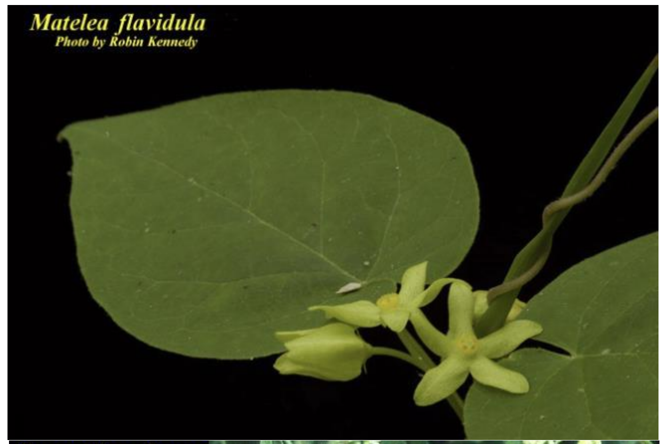
The monarch butterfly belongs to a group of butterflies collectively known as milkweed butterflies, and is related to the queen butterfly, *Danaus gilippus*, which is also found in Georgia. The larval forms feed exclusively on plants formerly in the milkweed family which are now included in the dogbane family (Apocynaceae). In Georgia, several species of milkweed occur naturally throughout the state depending on geographical location (milkweedinformation.pdf (uga.edu)), and although the most commonly recognized plants belong to the genus *Asclepias*, two other genera (*Cynanchum* and *Matelea*) are found in the state. Common examples of milkweeds include the butterfly weed, *Asclepias tuberosa* (Fig 3); the clasping milkweed, *Asclepias amplexicalis* (Fig 4); and the pinewoods milkweed, *Asclepias humistrata* (Figure 5). The other two genera are more twining and vine-like in their growth pattern (Fig 6 & 7), rather than the more upright growth pattern displayed by members in the genus *Asclepias*. The milkweed provides the developing larvae with cardenolides, a group of toxic steroids that are stored by the caterpillars and help defend them against predators throughout their lives (Parsons, 1965; Malcolm and Brower, 1989).

Similar to mosquitoes, the monarch displays complete metamorphosis during its life cycle (egg, larva, pupa, and adult), although all stages are completely terrestrial. In addition, the monarch larvae pass through a total of five (rather than four) instars before pupating and emerging as adults. The entire larval stage, from egg to butterfly, may take less than a month to complete, depending on temperature and other conditions. Survival rates from egg to fifth instar vary from study to study, but are generally low, falling between 7-12% (Borkin, 1982, Nail et al., 2015a) or even lower (De Anda and Oberhauser, 2015), and in at least one case no larvae were found after the first instar (Calvert, 1996).

Today, one of the major problems facing the monarch butterfly is the loss and fragmentation of larval habitat. Throughout its range, the conversion of areas to farmland or residential subdivisions has drastically reduced milkweed availability to egg-laying adults. In addition, the rise in genetically modified crops, particularly those with herbicide tolerance, have accelerated the use of herbicides and further depleted milkweed numbers across the nation. Even crops modified for insect resistance, such as Bt maize (corn encoded for insecticidal proteins from *Bacillus thuringiensis*) have been linked to larval mortality (Hansen and Obrycki, 2000), and implicated as a possible contributor to a reduction in the overall fitness of monarch populations (Oberhauser et al., 2001). However, the impact of newer strains of Bt corn on monarch populations should be low (Sears et al., 2001). The wide use of neonicotinoids on croplands across the US may also be a potential hazard to monarchs (Pecenka and Lundgren, 2015; Forister et al., 2016). However, with the exception of human development, these points are not relevant in areas like Chatham County, where agriculture is not widespread, and croplands occupy an insignificant amount of the total acreage of the county.

There are numerous other threats faced by the monarch. First instar larvae are at risk of becoming mired in the latex sap of the milkweed itself (Zalucki et al., 2001). Larvae are also susceptible to numerous predators, parasites, and parasitoids. Borkin (1982) observed that several species of hemipterans, spiders, lacewing larvae, and vespid wasp prey upon *D*. *plexippus*, and although the aposematic coloration of the larvae may be adequate defense against vertebrate predators, mortality by invertebrate predators is substantial. Hermann et al. (2019) recorded numerous species of arthropods across nine orders (including beetles, earwigs, and crickets) that fed on eggs or neonate larvae in a lab setting augmented by field observations. In some areas of its range fire ants, *Solenopsis invicta*, may cause significant losses to eggs and larvae (Calvert, 1996). In Kentucky, an invasive paper wasp, *Polistes dominula*, has been shown to not only prey upon monarch larvae, but also nest in structures intended as butterfly "hibernation boxes" (Baker and Potter, 2020). *Ophryocystis elektroscirrha*, a protozoan parasite, that is known to occur in both queen and monarch butterflies, appears to cause a weakened condition in emerging adults that can lead to death (McLaughlin & Myers, 1970), decreased larval survival, smaller adult size, and shorter adult lifespans (Altizer & Oberhauser, 1999). Parasitic tachinid flies can also be a major cause of mortality in the monarch as well (Oberhauser et al., 2017; Geest et al., 2019).

Abiotic factors may also play a role in the overall health and density of monarch populations. Extremely high temperatures during larval development can lead to smaller adults, slower larval development, and reduced survival rates, while extremely cold temperatures prevent eggs from hatching and lowered larval survival (Nail et al., 2015b). Drought conditions during the fall migration period limits the availability of nectar sources, and interferes with the lipid reserves in overwintering monarchs, which can lead to starvation (Brower et al., 2015). In addition, winter survival can be drastically altered by winter storms in the overwintering localities of Mexico (Calvert et al., 1983; Brower et al., 2004). Survival following severe winter storm



events may also be influenced by the overall health of the forest occurring at the site, as an intact forest with large trees provide an umbrella and blanket, which help shield overwintering monarchs from freezing rains and extreme cold (Anderson and Brower, 1996; Brower et al., 2009).

It seems unlikely that work involving the control of mosquito larvae would have any direct effects on monarch populations. Many species of butterflies are frequently found congregating around the edges of wet spots, mud puddles or other places holding water that could serve as mosquito larval habitat. This activity is often referred to as mud-puddling or simply puddling and is generally associated with obtaining sodium or other nutrients usually by male butterflies (Boggs and Jackson, 1991). Theoretically, butterflies could become exposed to larvicides applied to such niches, although, little is known about the effects of products used in the control of mosquito larvae on the adult monarch. One product used to control mosquito larvae, spinosad, has been used to control many caterpillar pests in vines, pome fruit and vegetables, but has been safely used on flowering plants without causing undue risk to honey bees (Miles, 2003).

Impacts from mosquito control operations on monarch populations would most likely be attributed to adult mosquito treatments, such as the event that occurred in North Dakota (Hundreds of Butterflies Killed in 'Monarch Massacre' After Mosquito Spraying in North Dakota (msn.com)). This massive kill appears to have occurred through an unfortunately timed mosquito spraying operation coinciding with the annual migration of the monarch in this region. However, in general mosquito adulticide missions are not usually associated with massive non-target mortality. Jensen et al. (1999) showed that flying insect abundance declined after applications of pyrethrin, malathion, or permethrin, but rebounded within 48 hours. Davis et al. (2007) indicated that risk quotients were low for six commonly used adulticides (d-phenothrin, resmethrin, permethrin, pyrethrin, malathion, and naled) as well as piperonyle butoxide (PBO), and risks to ecological receptors most likely are small from ULV insecticides applied through a mosquito management program. Also, because most ULV work is done after sunset, and monarch butterflies rarely are active at night (see Neck, 1976), conflicts with adult monarchs should be minimal from adult mosquito control efforts.

It has been shown that pesticide residuals deposited on host plants can cause mortality in monarch larvae (Oberhauser et al., 2006; Oberhauser et al., 2009; Giordano et al., 2020). Monarch larvae that fed on leaves exposed to deltamethrin showed increased mortality compared with those in a control group and impacts to fitness were generally greater in larvae feeding on host plants located closer to the spray source (Giordano et al., 2020). Only three of 192 monarch larvae survived to adulthood when fed milkweed leaves treated with a permethrin product designed for barrier use (Oberhauser et al., 2006). Similarly, Oberhauser et al. (2009) found that when exposed to resmethrin at field application rates, larvae exhibited increased mortality and development times, but also indicated that exposure to ULV resmethrin applications are likely to be less toxic to non-target herbivores than exposure to permethrin barrier treatments. Unfortunately, resmethrin no longer is registered for sale in the state of Georgia, and production of this product has been discontinued (E. English, pers. comments).

Much of the work concerning non-target effects of adulticides used in mosquito control focus upon honeybees, *Apis mellifera* (Colburn and Lanford, 1970; Caron, 1979; Zhong et al., 2003; Zhong et al., 2004; Chaskopoulou et al., 2014; Rinkevich et al., 2017; Pokhrel et al., 2018). These studies varied considerably by application method and products used. Colburn and Langford (1970) reported naled with a synergized pyrethrin was the most toxic to caged honey bees followed by naled, with malathion being the least harmful in their test using truck-mounted equipment. However, Caron (1979) indicated that malathion formulations killed more bees than either naled or pyrethrum in his work. Rinkevich et al. (2017) in tests with permethrin, prallethrin/sumithrin, malathion, and resmethrin found lower bee mortality compared with mosquito mortality, especially at lower label rates and greater distances. Pokhrel et al. (2018) recorded no significant differences in bee mortality, colony health or detoxification enzyme activities between treated and control sites from ground applications of resmethrin, prallethrin and sumethrin, and deltamethrin, and concluded that proper application of insecticides by truck results in little or no exposure and minimal effects on honey bees.

As far as aerial treatments are concerned, Chaskopoulou et al. (2014) found no significant non-target mortality in honey bees, mealy bug destroyers (*Cryptolaemus montrouzieri*) or green lacewings (*Chrysoperla carnea*) from applications containing unsynergized deltamethrin or phenothrin (i.e., sumithrin). Products containing a synergized pyrethrin applied aerially did not significantly affect caged non-target sentinel arthropods (dragonflies, *Sympetrum corruptum*; yellow garden spiders, *Argiope aurantia*; alfalfa butterflies, *Colias eurytheme*; and honeybees), although a measurable impact on a wide range of small-bodied arthropods was observed (Boyce et al., 2007). Likewise, Kwan et al. (2009) found that a single ULV aerial application of synergized pyrethrin affected a variety of small non-target arthropods, but thought these effects are likely to be short lived at the population level.

Zhong et al. (2003) suggested that aerial ULV application of naled using a flat-fan spray system does adversely affect honey bees and honey yield. They found that naled was highly toxic to bees upon direct contact but found no evidence that naled deposits were hazardous to bees in their hives. In addition, they noted that increased frequency of naled treatments could eventually reduce honey yield due to cumulative bee loss from each treatment. In later work, Zhong et al. (2004), concluded that a high-pressure nozzle system substantially reduced environmental contamination from applications and lessened bee mortality. Breidenbaugh and de Szalay (2010) reported that aerial spraying with naled in South Carolina successfully decreased pest numbers while impacts to non-target communities were less pronounced. Additionally, the physical properties of naled may also help in reducing detrimental effects on non-targets, like the monarch. Chatham County Mosquito Control (CCMC) currently uses Trumpet® EC (Amvac Chemical Corporation) in most of our aerial adulticide work, which degrades rapidly, and should not accumulate on vegetation for long periods. Tests carried out with a stronger form of naled (Dibrom concentrate, 85% AI), found half-life varied depending on light and humidity, and was as short as 1.37 hours in direct sunlight to 8.17 hours in a dark chamber at 46.9% relative humidity (Tietze et al., 1996). In this study, higher humidity accelerated the rate of decay, although a number of complex processes control the fate of naled in a terrestrial environment.

Figure 8 Monarch with wing tag

To alleviate some of the risk to adult monarchs, programs could avoid treating areas where butterflies are plentiful, such as rich nectar sources and/or areas containing stands of milkweeds. Mosquito control staff could begin identifying probable habitats within their respective areas in the near future. In operations that use ground based ULV trucks, a roadside survey of spray routes could be performed to determine where milkweed patches exist. Stands of milkweed could be located, mapped, and easily omitted from spray operations to prevent deposition on these plants. Programs using aerial applications may require more extensive survey work since these treatments blanket a large continuous area, rather than drift with the wind a relatively short distance (ca 300 feet) from a roadway.

Observations on adult monarch activity, particularly during the fall of the year when this species bands together to migrate, may be extremely helpful in determining when to avoid mosquito treatments because such masses are travelling through the area. Movement in adult monarch butterflies is often derived from the work of citizen scientists conducting butterfly counts during some stage in the monarch's annual cycle (see Oberhauser et al., 2009). In addition, the recapturing of tagged butterflies (see Fig 8) also provides information on the direction, distance, and speed of movements, although recapture rates of tagged individuals are rather low (Urquhart and Urquhart, 1976a; 1976c; McCord and Davis, 2010; Oberhauser et al., 2015). Even so, the timing of such migrations varies from year to year and by location and fall migration patterns in Georgia are poorly documented (https://monarchwatch.org/tagging/index.html#recoveries. Older data (1970-1975) indicated that along the Gulf Coast of northern Florida the peak of migration activity occurs between October 20-25, and on one or two of these days this activity may involve thousands of individuals (Urquhart and Urquhart, 1976b). Likewise, large waves of monarchs have been observed in northern Georgia in late October (Howard and Davis, 2009). Yet, monarchs have also been reported to overwinter (Howard et al., 2010) or even maintain winter-breeding populations (Satterfield et al., 2015) in coastal Georgia. Thus, populations in lower Georgia may be composed of both migratory and resident individuals during the fall and winter months. Estimates for the timing of fall migration intervals are available on-line based upon latitude (https://www.monarchwatch.org/tagmig/peak.html).

On the flip side of the fall migration is the remigration of butterflies occurring in the spring. Travel corridors for this re-entry process from overwintering areas into the eastern portions of United States may be less organized and more drawn out than the fall migration event. Evidence, including information collected in Georgia, indicates few monarchs occur east of the Appalachians during late spring, and this region may actually be repopulated by the offspring of butterflies returning to the states from overwintering grounds in Mexico that were likely reared along the Gulf Coast (Brower, 1996). Movement of individuals derived from winter-breeding populations of monarchs in south Florida probably also account for a portion of the reintroduction of the monarch along the Atlantic Coastal Plain (Brower, 1996; Knight et al., 1999).

Northward movement from northern and central Florida likely correlates with milkweeds in this region becoming unsuitable for monarch oviposition, which generally occurs by mid-May (Knight et al., 1999).

One last aspect concerning monarch ecology that should be addressed is the increasing interest by the public to establish backyard "butterfly gardens." Such habitat restoration projects established by "citizen scientists" throughout the nation has met with mixed reviews in the scientific community. Levy and Conner (2004) questioned whether the capability of these habitats could support larvae to maturity in another butterfly species, the pipevine swallowtail, *Battus philenor*. They felt that without evidence of juvenile abundance and survival rates in such gardens matching or exceeding those of natural sites that gardens would act as population sinks in this species. In other words, these gardens would tend to attract butterflies away from better quality habitats where larvae are more prone to reach adulthood. Butterfly gardens may also serve as ecological traps by making larvae more susceptible to repeated predation from *Polistes* wasps, which generally thrive in a more metropolitan setting that provides ample nesting sites in sheltered areas associated with man-made structures (Baker and Potter, 2020). Even unsuccessful *Polistes* attacks on other species of lepidopteran larvae have been attributed to indirect negative effects caused by movement of larvae from ideal feeding sites to less desirable sites that extended the larval developmental period and decreased growth rates in the caterpillar (Stamp and Bowers, 1991). Lastly, it has been noted that the tropical milkweed, *Asclepias curassavica*, a commonly available exotic species used in many gardens may interfere with migration patterns in the milder climatic areas of the U.S. In such areas, this plant continues to grow and provide a continuous supply of food to a winter generation of larvae (Satterfield et al., 2015). In addition, monarch survival was shown to be five times lower on *A. curassavica* at warmer temperatures than at ambient temperatures, and thus this plant could serve as an ecological trap considering possible effects from global warming moving forward (Faldyn et al., 2018). Additionally, tropical milkweed has been shown to influence reproductive activity when monarchs feed on this plant as larvae or when adult female migrants encounter it in their travels (Majewska and Altizer, 2019).

Despite such problems associated with butterfly gardens, Baker and Potter (2018) confirmed that small urban gardens containing milkweeds are readily found and colonized by monarch butterflies. Geest et al. (2019) saw no difference in monarch survival between gardens with planted milkweed and conservation areas and suggested that gardens have the potential to aid the recovery of the monarch butterfly. Cutting and Tallamy (2015) did not see a significant difference in the cumulative sub-adult survival between garden site and natural sites. They further stated that more host plants were lost in natural sites than in gardens, and that milkweeds growing in gardens tended to be taller and had larger leaves. In their assessment for monarch restoration, Thogmartin et al. (2017) indicated that the contributions to the gain in milkweed density from the urban/suburban sector would be dependent on overall participation but could amount to between 3-10 percent of the additional milkweed habitat required to reach the overall goal of nearly doubling the overwintering population of monarchs in Mexico. The Monarch Waystation Program (https://www.monarchwatch.org/waystations/) lists guidelines for establishing butterfly gardens, and the Larva Monitoring Program, Journey North, and Monarch Watch are projects that involve volunteers across the United States and Canada to aid in monarch research. Data from such groups has been used to assess immature monarch survival (Nail et al., 2015), as well as the geography of the overwintering range of monarchs outside of Mexico in the southern United States (Howard et al., 2010).

The protection of butterfly gardens by mosquito abatement organizations may somewhat mimic how backyard honey bee colonies are handled by CCMC. Bee owners are encouraged to register the location(s) of their hive(s) in our notification system (SwiftReach) which can generate a message by phone, text, or email to an individual a day in advance to a scheduled aerial treatment, allowing the resident time to protect the site. Again, as mentioned earlier regarding safeguarding milkweed habitat, in ground-based programs, exclusion areas can be easily formed where spray systems are turned off to prevent ULV products from settling on host plants. Of course, setting up such exclusion areas is reliant on citizen participation, and knowing where "butterfly gardens" are located.

Keep in mind that the monarch butterfly is currently not listed as a protected species. However, as a candidate species for listing, it is important that mosquito control agencies consider certain changes to their programs should protection be granted at some time in the near future. It is equally important to note that mosquito control operations probably have little effect on the overall declines observed on monarch populations throughout its range. Even so, by developing some type of action plan ahead of any pending protection for this species may prevent possible problems down the road, such as bad publicity or even a halt in service while developing a contingency plan.

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Contributed by:
Robert A. Moulis
Chatham County Mosquito Control

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The Georgia Mosquito Control Association

GMCA
c/o Kristin Reichardt
Richmond County Public Health
Richmond County Mosquito Control
1916 North Leg Rd
Augusta, GA 30909

www.GAmosquito.org