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Mosquito population dynamics during the establishment phase of a constructed desert wetland

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Mosquito Population Dynamics During the Establishment Phase of a Constructed Desert Wetland

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The Nature Preserve at the Clark County Wetlands Park is a constructed wetland that has the potential to produce new mosquito habitat. This thesis evaluates the potential for the development of a mosquito problem at the newly constructed wetland system by assessing the population dynamics of mosquitoes within the Nature Preserve. Based on data collected from May 2001 through January 2002, I describe fluctuations in mosquito genus and relative abundance during the first summer through winter period of wetland development.

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Introduction

The Nature Preserve, a 130 acre constructed wetland at the west end of the Clark County Wetlands Park (CCWP), consists of a series of five ponds that receive water from urban and storm runoff as well as shallow groundwater sources (U.S. Department of the Interior, Bureau of Reclamation, and Clark County Department of Parks and Recreation, 1998). When the ponds at the Nature Preserve were constructed in January 2001, there was little to no vegetation in or around them. Approximately one month later, a planting effort provided the beginning of vegetation establishment. Throughout the first year of wetlands establishment, the ponds at the Nature Preserve changed dramatically from bare to lush (Figure 1.1 and 1.2).

Figure 1.1: March 2001

Figure 1.2: August 2001
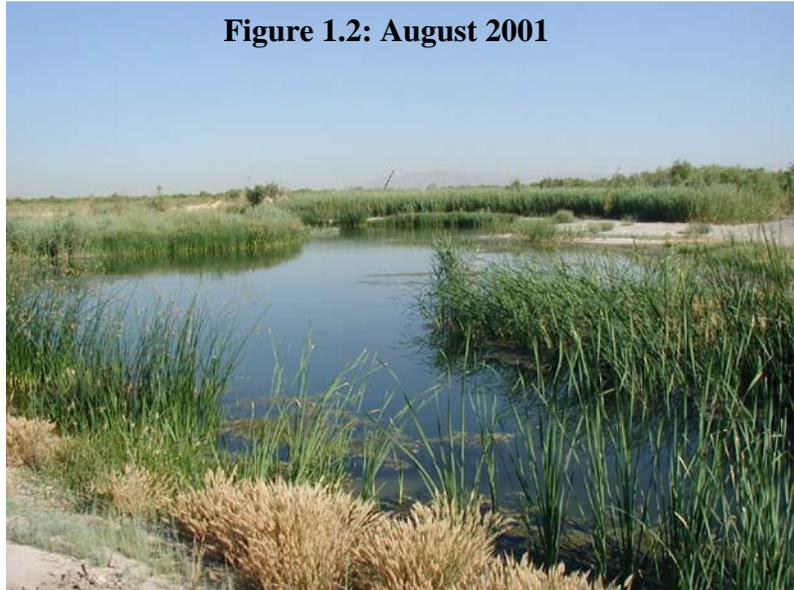
Because the park is designed to attract wildlife and humans alike, questions have surfaced concerning possible impacts the two may have on one another. One main concern is that in addition to providing habitat for birds, fish, and mammals, the ponds will serve as a prime breeding location for mosquitoes. The purpose of this study is to determine if these concerns are warranted by assessing the population dynamics, the way a population as a whole changes over time, of mosquitoes at the Nature Preserve. In order to describe the mosquito population dynamics within the Nature Preserve, I have conducted monthly monitoring of mosquitoes and plotted the results on a behavior-time graph.

With constructed wetlands becoming increasingly common in urban areas, a relatively small but pertinent body of literature has developed over the past few decades concerning their ability to engender mosquito problems and ways to avoid this occurrence while maintaining the wetland's desired properties (Batzer & Resh, 1992; Walton & Workman, 1998; Russell, 1999). Russell's (1999) overview of the relationship between constructed wetlands and mosquitoes concludes that deeper habitats with more open water and cleaner steeper margins produce fewer mosquitoes. In fact, there seems to be a general consensus that the most important factor in whether or not a particular constructed wetland will cause a population explosion is in the design itself (Russell, 1999; Workman & Walton, 2000; Lilley & Labatiuk, 2001). This includes features such as vegetation, water depth, and steepness of margins (or edges of the body of water).

The type, density, and distribution of vegetation are also important features determining mosquito abundance. One study on a freshwater marsh in California discovered that *Culex tarsalis* was significantly associated with some emergent plants

such as *Typha* (cattail) but not others such as *Scirpus* (sedges and bulrushes) (Walton *et al.,* 1990). Additionally, a study of an experimental wetland in Southern California found that one-phase marshes, containing continuous vegetation throughout, produced significantly more mosquitoes than 3-phase marshes, which consisted of two vegetated regions separated by a region of deeper, open water (Walton & Workman, 1998).

Some studies have found that water depth and steepness of margins have a significant impact on mosquito production, but this association is most likely a result of the affinity of emergent vegetation for shallow water and gently sloping margins. While Batzer and Resh (1992) found that shallow (< 30 cm) vegetated water typically supports more mosquito breeding than deep (> 60 cm) pools with steep edges and no emergent vegetation, a later study found no association of emergence of *Culex* species with water depth independently (Workman & Walton, 2000).

Hypothesis

A wetland system provides many of the favorable characteristics that mosquitoes require for comfort, survival, and reproduction. The larvae and pupae of mosquitoes are exclusively aquatic, so all mosquito species require temporary or permanent standing bodies of water for laying their eggs (Walker & Newson, 1996). Mosquitoes are also sensitive to changes in humidity and prefer a range of 30 to 80 percent relative humidity (Bates, 1949). In our arid climate, wetlands may provide a microclimate suitable to mosquitoes. Plants also play a crucial role in creating an ideal mosquito habitat. Vegetation provides shelter for mosquitoes while not in flight, and both males and females require nectar of flowering plants as a food source (Walker & Newson, 1996).

Additionally, female mosquitoes require blood in order to produce eggs, and many feed on birds, which are abundant in a wetland habitat (Bates, 1949).

Nevertheless, a review of the literature suggests that the design of the Nature Preserve will not lead to elevated mosquito populations. Due to the open pond and stream structure, it will not be conducive to excessive mosquito production as long as vegetation is properly managed. In fact, Richard Hicks of Clark County Vector Control (CCVC) indicates that creation of the CCWP as well as concurrent Las Vegas Wash reconstruction and preservation activities may actually affect mosquito dynamics in a positive way (personal communication, February 28, 2002). In other words, the channeling and proper management of these resources will result in fewer marshy areas that will in turn lead to lower mosquito production.

Based on monitoring data collected by CCVC, there are six mosquito genera that are known to occur in Clark County, NV: *Aedes*, *Culex*, *Anopheles*, *Culiseta*, *Psorophora*, and *Uranotaenia*. Of these six, the three genera that are most likely to be encountered at the Nature Preserve are *Anopheles*, *Culex*, and *Culiseta*. Also based on CCVC monitoring data, I would expect the genera *Culex* and *Anophles* to peak during the summer months, while *Culiseta* should peak in the winter. The dynamics for total mosquitoes for the years 1999 and 2000 at a site in close proximity to the Nature Preserve show a peak in September and August respectively (Figure 2), so I would expect to see the same behavior in mosquitoes at the Nature Preserve.

Figure 2: CCVC Data for Las Vegas Stadium Mosquito Trends (modified from Clark *et al*.2000)
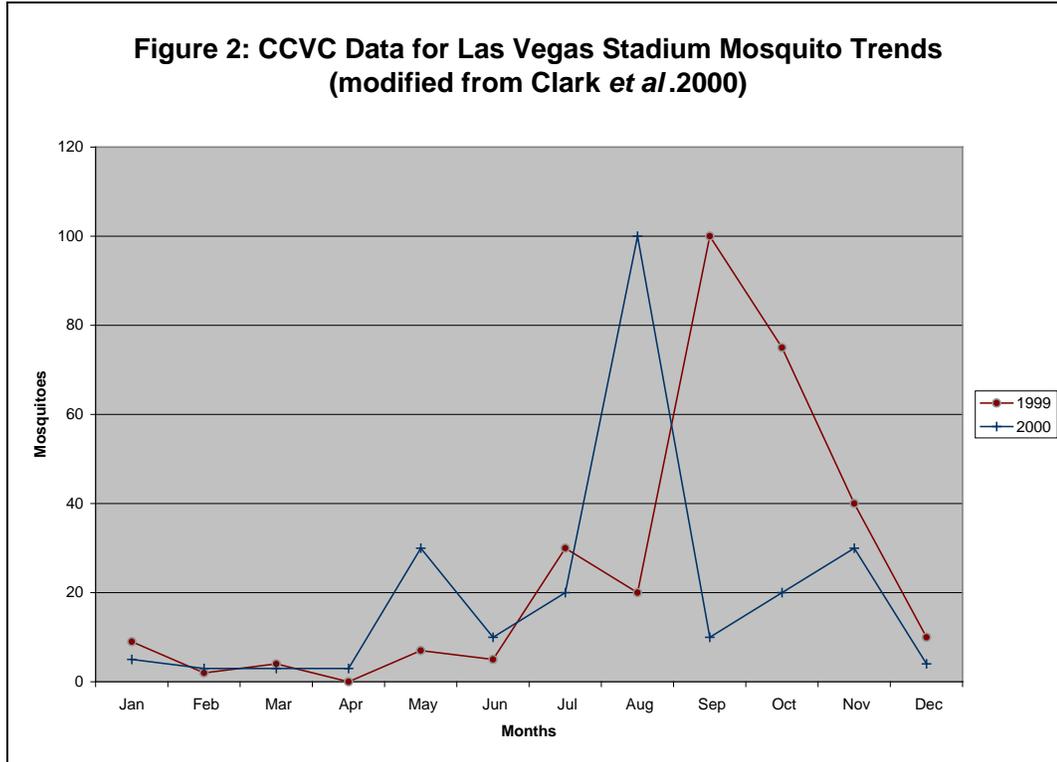
Methods

This section consists of the following three sub-sections: Subjects and Design, Review of Monitoring Methods, and Procedure and Materials.

Subjects and Design

This project was designed to determine the effect of the creation of the Nature Preserve on mosquito populations. I did this by describing the population dynamics of adult mosquitoes within the Nature Preserve. To serve this purpose, collections of host-seeking adults were conducted monthly beginning in March 2001 and will continue indefinitely. The data analyzed for this thesis was collected from May 2001 through January 2002 (data from March and April 2001 was not used in the analysis because of the small sample size). This period encompasses the first summer through winter period

of the first year of wetland establishment. Each monthly trapping event consisted of three consecutive nights of trapping at 3-5 locations within the CCWP Nature Preserve (Appendix A).

Review of Monitoring Methods

The most appropriate method of monitoring mosquito populations depends upon the goal of the study. Russell (1999) asserts that assessment of the full extent and importance of mosquito production requires comprehensive surveillance with regular larval surveys and concurrent routine adult collections. Larval sampling is important to detect incipient mosquito infestations and can confirm that mosquitoes are being produced locally. This method, achieved by dipping, was used in a study of the effects of marsh design on mosquito abundance (Walton & Workman, 1998). In this case, larval samples were necessary to determine which areas of the marsh were more productive.

While larval sampling may indicate an abundance of immature mosquitoes, it may not translate into an adult "problem" due to predation or other ecological factors (Russell, 1999). Adult monitoring is a more direct approach when assessing whether or not a problem exists in an area. Two methods of collecting adult mosquitoes are described in the literature: emergence, which captures mosquitoes as they are emerging from the aquatic stage of the life cycle, and host-seeking, which captures adults by using CO_2 as bait (Workman & Walton, 2000; Walton & Workman,1999). A mosquito control strategy developed for the city of Phoenix briefly outlines two additional groups of mosquitoes that can be targeted for adult monitoring: gravid females (females that contain eggs), which are usually collected as they search for sites to deposit their eggs; and resting adults which consists of recently blood-fed females, newly emerged females,

and males (CH2M Hill, 1999). When assessing the efficacy of control measures against *Culex erythrothorax*, Walton and Workman used adult mosquitoes collected in emergence traps because this mosquito was underrepresented in larval surveys (1998).

Another method used to assess mosquito abundance is a mark-recapture study. The mark-recapture method was used for a study on a constructed wetland in southern California that determined dispersal of *Culex erythrothorax*. (Walton, Workman, & Tempelis, 1999) This was accomplished by collecting host-seeking females, marking by dusting them with a release-specific colored fluorescent dust, then releasing them.

When collecting host-seeking females, trap design is an important consideration. Traps may use a white or black light as an attractant, or they may use CO_2, a known attractant of mosquitoes (Reisen, 2000). Reisen (2000) concluded that CO_2 is the principal attractant of mosquitoes and that deleting the light source facilitates processing by eliminating unwanted insects. Traps baited with CO_2 were also found to be more effective than blacklight traps in an unpublished study on the CCWP Nature Preserve in that more mosquitoes were collected in the CO_2 traps with fewer unwanted insects (Benally, Clark, Feller, Johnson, Nanson, Newman, Nick, and Petit, 2001).

Additional recommendations for collections of host-seeking females indicate that placement of traps is also an important consideration. Traps should not be placed in open areas, over water, or over low vegetation (Lolthrop & Reisen, 1998). Also, the traps should be permanently-placed with the trap opening about five feet from the ground and should be run from late afternoon to early morning (CH2M Hill, 1999).

Procedure and Materials

Collection of host-seeking adult mosquitoes was used exclusively as the method for assessing mosquito population dynamics for several reasons. First, mosquitoes searching for a blood meal are potential disease vectors and are a nuisance to humans, so this is the life stage that is most significant to human populations. Additionally, adult mosquito populations are the primary indicator that a problematic level exists; while many larvae may be produced, ecological factors may prevent the development of an adult "problem." Finally, resource and time constraints prevented the use of a variety of methods, so host-seeking was chosen as the most efficient means of answering the question posed.

Host-seeking adult females were collected using an EVS trap baited with approximately two pounds of dry ice, which was placed in an insulated container directly above the trap. The traps were set in the evening and picked up the following morning in one of five locations within the Nature Preserve. Each trap-night was approximately 12 hours. The locations were selected near open water but within a vegetated area that provided some protection from wind. All traps were hung approximately five feet from the ground on Tamarisk trees, the predominant woody vegetation within the Nature Preserve.

When the traps were picked up, the trap contents were gently shaken to the bottom of the net, and the top was closed securely with a clip. The nets were then taken to the lab where they were placed into a freezer for approximately 10 minutes to kill the mosquitoes. The contents of each net were then emptied into a tray, counted, and sorted

by genus using low magnification. The total number of mosquitoes and number in each genus were recorded for each trap night (Appendix B).

In order to put this data into context, it must be compared to historical data on mosquitoes in the surrounding area. Richard Hicks, CCVC, has obtained this information continuously over the past several decades using a standard New Jersey-style light trap, which uses a 60-Watt light bulb to attract insects and a powerful fan to entrap them. Because the trap design and method used by Hicks differ substantially from those used to collect the Nature Preserve data, a comparison index must be created before any meaningful comparisons can be made between the CCVC data and the Nature Preserve data. To do this, I set the traps out side-by-side in order to determine a ratio between the results of the two different traps. This means the traps were running at the same times and on the same days. The traps were approximately 30 meters apart. The side-by-side trapping, conducted at a site approximately half a mile from the Nature Preserve, began in July 2001 and will continue indefinitely.

Results and Analysis

Nature Preserve Population Dynamics

The seasonal fluctuations in mosquito abundance are illustrated in Figure 3. This graph shows the average total monthly mosquito counts obtained within the Nature Preserve throughout the study period. Because each monthly trapping event consisted of three nights of trapping, the results for each month are reported as the average number of mosquitoes per trap-night for all of the traps set. Therefore, each point on the graph represents the mean for all traps for all three trap-nights. In May, August, September, and October, trap malfunctions occurred, so for these months, data were excluded for the

malfunctioning traps. [1]   The mean number of mosquitoes collected during the study

period is 43 mosquitoes per trap night. The maximum number occurred in August with

an average of 167 mosquitoes per trap night collected that month. The minimum

occurred in December with an average of 1 mosquito per trap night.   Figures 4, 5, and 6

illustrate the monthly fluctuations of each of the three genera that were found to occur

within the Nature Preserve: *Anopheles*, *Culex*, and *Culiseta* respectively.   The genus

Anopheles averaged 1 mosquito per trap night during the study period. This genus

peaked in June with an average of 27 mosquitoes collected per trap night and reached a

minimum of 0 mosquitoes per trap night in November and January.   The genus *Culex*

averaged 37 mosquitoes per trap night overall, reaching a maximum of 173 mosquitoes

per trap night in August and a minimum of 0 mosquitoes per trap night in December.

The genus *Culiseta* did not appear until September; excluding the preceding months, this

genus was at a maximum in October with an average of 13 mosquitoes per trap night and

reached a minimum of 0 mosquitoes per trap night in September. The mean for this

genus during the time it was present was 4 mosquitoes per trap night.

Side-By-Side Trapping

The results for the side-by-side trapping are shown in Figures 7, 8, 9, and 10.

The collection method used by Hicks is to let the New Jersey light trap run for a full

week before retrieving and reviewing the contents, so the first calculation necessary to

make the data comparable was to calibrate the trap periods . To achieve this, I converted

all of the CCVC data to average number of mosquitoes per trap night by dividing the total

mosquitoes caught by the number of nights the trap was run. It was then possible to

compare the results from the EVS trap located at the Duck Creek site (DC-H-1-M, see

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[1] The omitted data are those noted in Appendix B as fan off or weak.

Appendix B) to the results from the CCVC New Jersey trap located at the Duck Creek

site for the same week (Appendix C). Due to the widely differing scales of the results for

each trap, the data was normalized to percent of total mosquitoes caught per trap-night.

Figure 7 shows the side-by-side results for total mosquitoes. In this graph, results

for the EVS trap show a peak in August which then declines rapidly; however, the New

Jersey trap shows a peak in October. Figure 8 shows a comparison for the genus *Culex*.

Here, results for both the EVS and New Jersey traps show a peak in August followed by a

decline over the following two months. In Figure 9, a comparison for the genus

Anopheles, results for the EVS trap show the highest peak in August with a second lower

peak in December. The results for the New Jersey trap show a peak in July which

crashes in August and climbs to a second peak in November. The side-by-side results for

the genus *Culiseta* (Figure 10) show the strongest correlation between the two sets of

data. For both the EVS and the New Jersey trap, the genus *Culiseta* appears in October

where it is at its peak, then declines markedly to a trough in December.

Due to the apparent visual correlation between the normalized curves for the

genera *Culex* and *Culiseta*, theses genera were used to calculate a ratio between the two

different trap types. The ratios were calculated by dividing the results for mosquitoes per

EVS trap night by the results for mosquitoes per New Jersey trap night. Tables 1 and 2

show the results for these calculations. For the genus *Culiseta*, there are only two non-

zero points from which a ratio may be determined. These points occur in October and

November and have ratios of 6 and 7 respectively. For the genus *Culex*, there are three

non-zero points from which a ratio may be determined. For July, August, and September,

the ratios are 21, 39, and 84 respectively.

Figure 3: Average Number Mosquitoes per Trap-night (all genera)
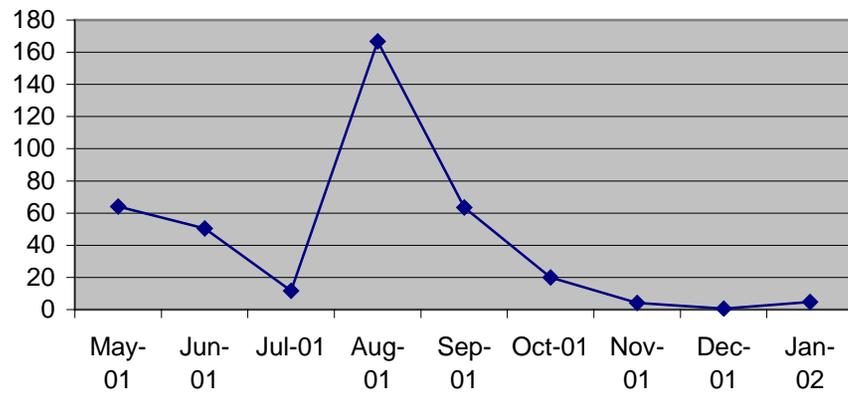

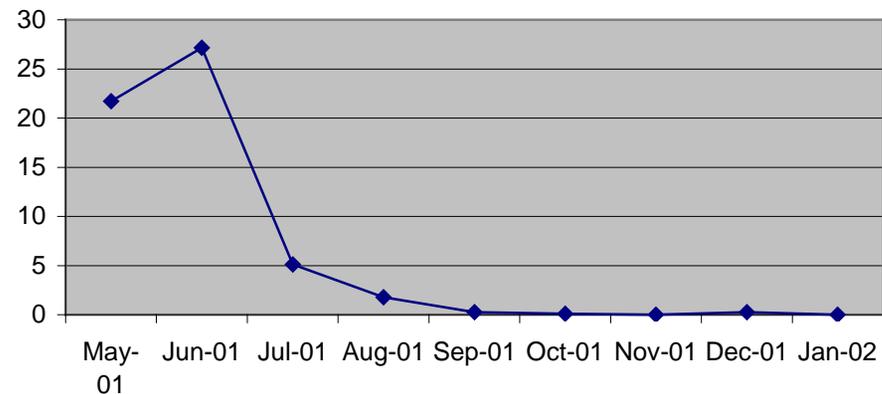Figure 4: Average Number *Anopheles* per Trap-night

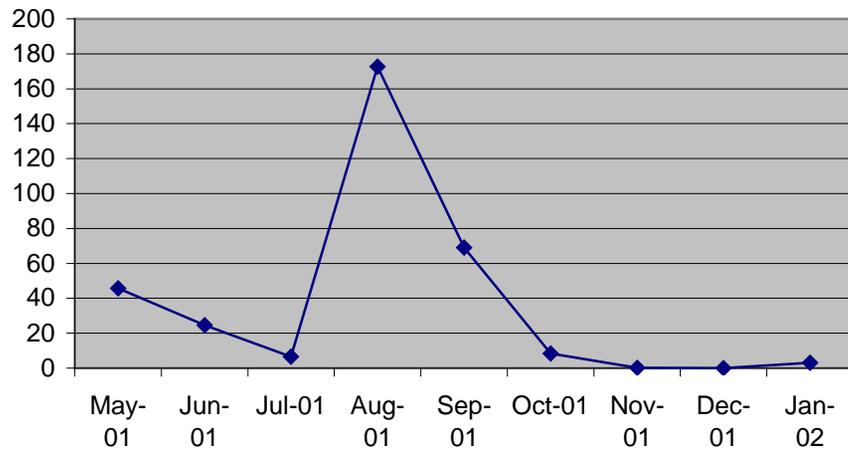Figure 5: Average Number *Culex* per Trap-night

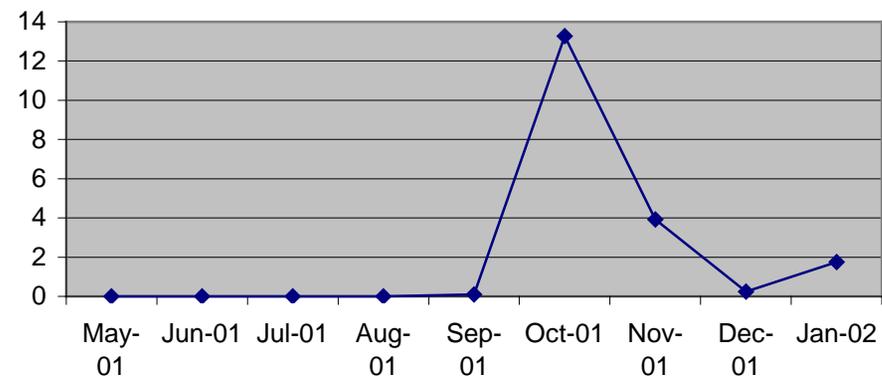Figure 6: Average Number *Culiseta* per Trap-night

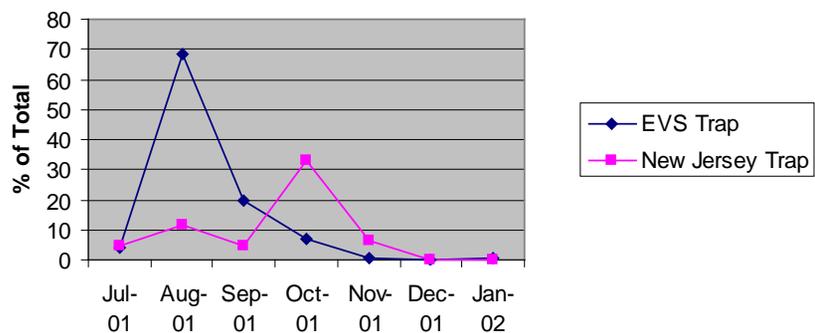**Figure 7: Comparison of Total Mosquito Counts for Duck Creek Site**

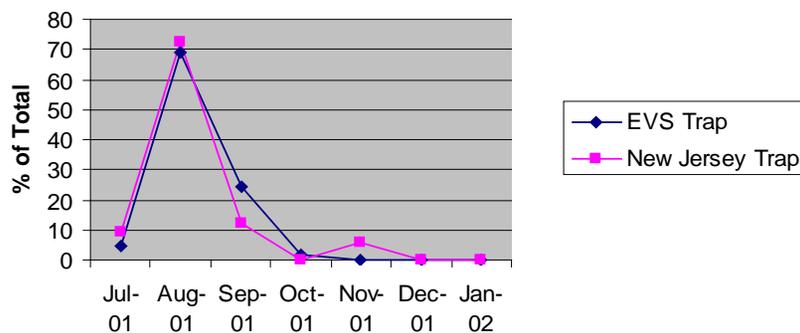**Figure 8: Comparison of *Culex* Counts for Duck Creek Site**

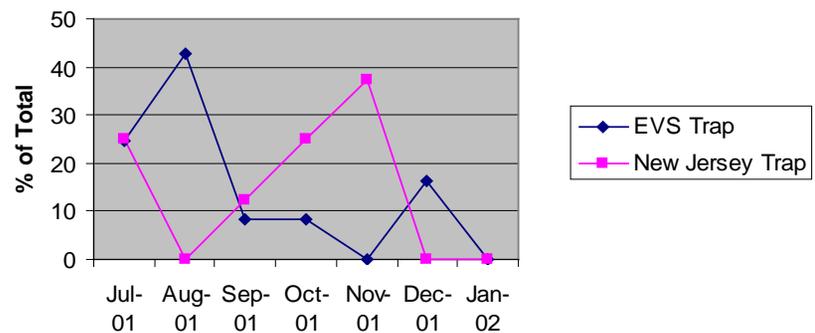**Figure 9: Comparison of *Anopheles* Counts at Duck Creek Site**

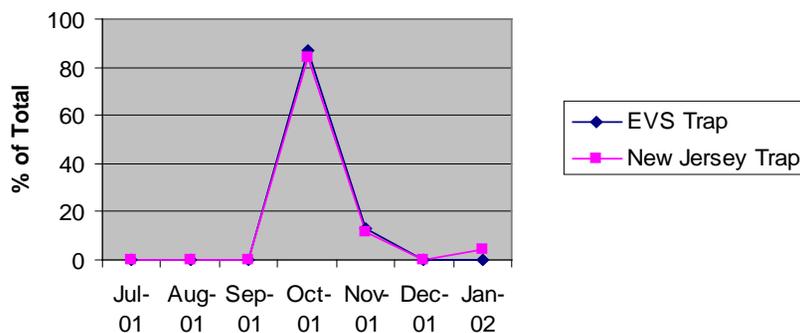**Figure 10: Comparison of *Culiseta* Counts for Duck Creek Site**

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Table 1: Ratio Between Two Traps for genus *Culiseta*—EVS: New Jersey

	EVS	New Jersey	Ratio
July	0	0	**0**
August	0	0	**0**
September	0	0	**0**
October	13.33333	2.142857143	**6**
November	2	0.285714286	**7**
December	0	0	**0**
January	0	0.111111111	**0**

Table 2: Ratio Between Two Traps for genus *Culex*-- EVS: New Jersey

	EVS	New Jersey	Ratio
July	9	0.428571429	**21**
August	134.25	3.428571429	**39**
September	48	0.571428571	**84**
October	3.6666666	0	**0**
November	0	0.285714286	**0**
December	0	0	**0**
January	0	0	**0**

Discussion

The population dynamics for mosquitoes within the Nature Preserve follow expected trends. For the genus *Culex*, the peak occurred in August which corresponds with the expected dynamics. The genus *Anopeles* peaked in June which also agrees with the expected summer peak. *Culiseta*, a winter species, is most abundant in October which is when the temperature in Las Vegas begins to fall. For all genera, the trend line for the year 2000 (Figure 2) is very similar to the trend line for the Nature Preserve dynamics (Figure 3).

One question concerning this data is the following: how do these numbers relate to the population as a whole? Unfortunately, I found no credible literature that describes the relationship between the catch of a CO_2-baited trap and the population of mosquitoes it describes, so these numbers can not be used to make conclusions about the actual number of mosquitoes in the Nature Preserve. They can, however, be used to evaluate trends and to make relative comparisons in the future. Another concern is that in using the method of collecting only host-seeking adult mosquitoes, a limited amount of information can be drawn for management purposes. Since there is no way of knowing the origin of the mosquitoes trapped in the Nature Preserve using this method, even a rapid increase would not indicate with certainty that the mosquitoes were being produced in the Nature Preserve; larval sampling would be needed.

The results from the side-by-side trapping suggest some correlation but are mixed. In the comparison of total mosquito dynamics, there is no strong correlation between the two sets of results; however, there is a strong correlation between results for the genera *Culex* (Figure 8) and *Culiseta* (Figure 10). The pattern for total mosquitoes is likely due

to the pattern for the genus *Anopheles* (Figure 9) which shows no correlation at all

between the two trap types. Due to the inconsistency in the comparisons of total

mosquitoes and the genus *Anopheles*, they cannot be use to calculate a ratio, so the

workable data is narrowed considerably. Also, the remaining two genera that can be used

for ratio calculations have few non-zero points. Due to the extremely low number of data

points, no conclusion can be made as to an across-the-board ratio between the two traps.

The only rough deductions that may be made is that the CO_2-baited EVS traps catch

substantially more mosquitoes than the New Jersey light traps and that the ratios between

the two may likely vary between species.

The reason why *Anopheles* genus shows a different trend between the two trap

types is not clear. To investigate this further, a longer data record would be needed. One

possible explanation is that this genus prefers one trap over the other. It is also possible

that the close proximity of the two traps caused a measurement error. Another possibility

is that since the New Jersey trap yields more males than the EVS trap and the total

number of mosquitoes (males and females) was used to calculate the ratio, the presence

of male mosquitoes may explain the differences for this genus.

Historical trends for mosquitoes are illustrated in Figure 11. These data were

collected by CCVC using a New Jersey light trap at a site in close proximity to the site of

the current Nature Preserve. Figure 11 shows a plot for the month of September for the

years 1974-2000. During this time period, there has been an obvious decline in mosquito

numbers, with peaks greater than 2000 mosquitoes per week in the 1970s, which equates

to approximately 300 mosquitoes per trap night. Even assuming a conservative ratio of

1:10, this would equate to 3000 mosquitoes per trap night in a CO_2-baited trap, which is

much higher than current numbers. This suggests strongly that mosquito populations are much smaller than they were in the 1970s.

In order to better determine a quantitative correlation between the two trap types, continued side-by-side monitoring should be conducted over the next few years to expand the set of comparable data. Additionally, monitoring within the Nature Preserve should continue, and in the event that a problem occurs, larval collections should be conducted to determine if the problem is originating from the Nature Preserve.

Figure 11: CCVC Data for Mosquito Trends at Las Vegas Stadium
(as reported by Clark *et al.* 2000)
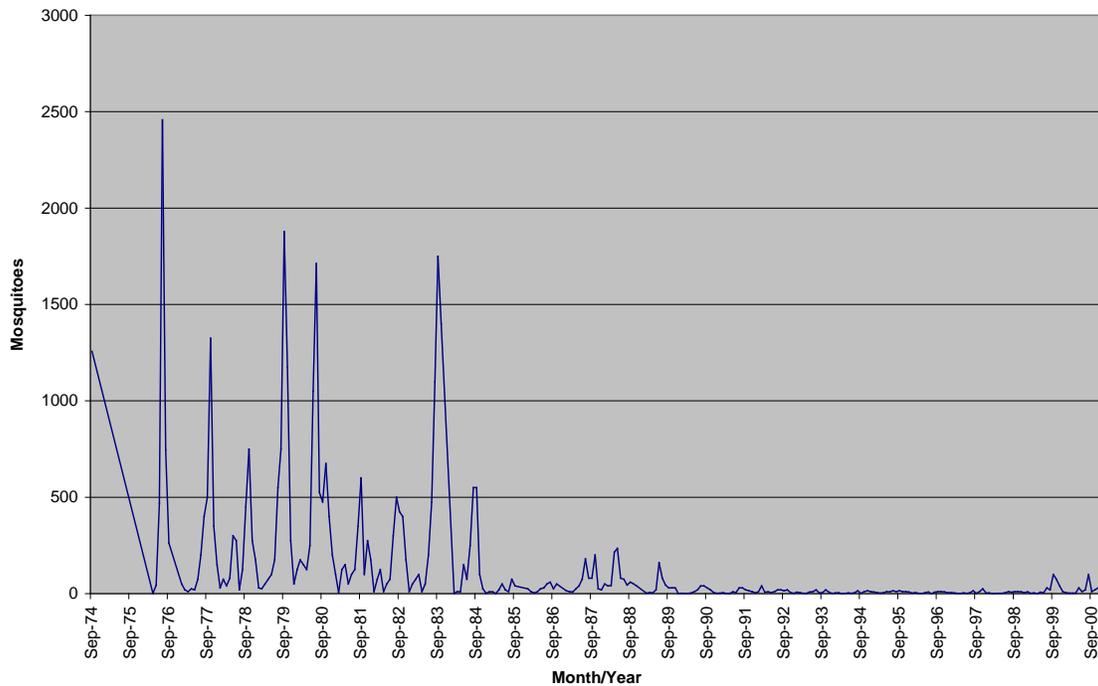
Literature Cited

Bates, M. (1949). *The Natural History of Mosquitoes*. New York: MacMillan.

Batzer, D.P., & Resh, V.H. (1992). Wetland management strategies that enhance waterfowl habitats can also control mosquitoes. *Journal of the American Mosquito Control Association, 8,* 117-125.

Benally, D., Clark, R., Feller, J., Johnson, E., Newman, A., Nanson, J., Nick, K., & Petit, B. (2001). Mosquito emergence in the Nature Center at Clark County Wetlands Park. Unpublished report.

C2HM Hill. (1999). *A mosquito control strategy for the Tres Rios demonstration constructed wetlands*. Phoenix, AZ: C2HM Hill.

Lolthrop, H.D. & Reisen, W.K. (date) Host-seeking patterns of mosquitoes in microhabitats of the Coachella Valley, California.

Reisen, W.K., Meyer, R.P., Cummings, R.F., & Delgado, O. (2000). Effects of trap design and CO2 presentation on the measurement of adult mosquito abundance using Centers for Disease Control-style miniature light traps. *Journal of the American Mosquito Control Association, 16,* 13-18.

Russel, R.C. (1999). Constructed wetlands and mosquitoes: health hazards and management options: an Australian perspective. *Ecological Engineering, 12,* 13-18.

U.S. Department of the Interior, Bureau of Reclamation, Clark County Department of Parks and Recreation. (1998). Final Program Environmental Impact Statement for the Clark County Wetlands Park.

Walker, E.D., & Newson, H.D. (1996). Culicidae. In R.W. Merritt & K.W. Cummins (Eds.), *An Introduction to the Aquatic Insects of North America* (pp. 571-590). Dubuque, IA: Kendall/Hunt.

Walton, W.E., Workman, P.D., & Tempelis, C.H. (1999). Dispersal, survivorship, and host selection of *Culex erthrothorax* (Diptera: Culicidae) associated with a constructed wetland in Southern California. *Journal of Medical Entomology, 36,* 30-40.

Walton, W.E., & Workman, P.D. (1998). Effect of marsh design on the

abundance of mosquitoes at a constructed wetland in Southern California. *Journal of the American Mosquito Control Association, 14,* 95-107.

Walton, W.E., & Workman, P.D. (1998). Effectiveness of control measures against mosquitoes at a constructed wetland in Southern California. *Journal of Vector cology, 23,* 149-160.

Workman, P.D., & Walton, W.E., (2000). Emergence patterns of *Culex* mosquitoes at an experimental constructed treatment wetland in Southern California. *Journal of the American Mosquito Control Association, 16,* 124-130.

Acknowledgements

Appendix A: Trap locations within the CCWP Nature Preserve