COMPARISON OF FOUR TECHNIQUES FOR SAMPLING WETLAND HEMIPTERA (HETEROPTERA, AUCHENORRHYNCHA)

by

Brandon B. Page

An Abstract
of a thesis presented in partial fulfillment
of the requirements for the degree of
Master of Science in the Department of Biology
University of Central Missouri

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Abstract

Insect sampling techniques can result in different estimates of species richness, diversity, and evenness. Hemipteroid insects were collected within a freshwater marsh over the course of three months, in Van Meter State Park, Saline County, Missouri. Techniques utilized were three vacuums, the D-Vac, G-Vac, E-Vac, and sweep netting in order to determine the most efficient sampling method. All three sampling months were significantly different from each other (*P* =.001). There was a significant difference among the sampling methods (*P* =.003). The D-Vac collected the largest number of specimens (1015), followed by the G-Vac (670), the E-Vac (280), and the sweep net (31). The D-Vac and G-Vac produced nearly the same number of unique species(D-Vac=15, G-Vac=14), nearly identical total number of species (D-Vac =30, G-Vac=28), and had similar diversity values (D-Vac=1.63, G-Vac=1.45), suggesting that these techniques are similar in effectiveness. The E-Vac collected the fewest number of unique and total species out of the vacuum techniques (3 unique species, 14 total species). The sweep net collected the least number of unique and total species out of all the sampling techniques (0 unique species, 7 total species) suggesting it is was not an effective sampling technique for marsh dwelling hemipteroid insects. All three vacuum techniques have different advantages and either a D-Vac or G-Vac should be used to sample wetland Hemiptera.

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CHAPTER 1
INTRODUCTION

Survey of Collecting Techniques

Various methods have been employed to sample insects in natural communities. Common methods include sweep nets, sticky traps, intercept traps, pitfall traps, and suction devices (Gibb and Oseto 2006). Each of these techniques has advantages and disadvantages. Net techniques and stationary traps are often unable to reach the lower strata of plant communities (Lowe et al. 2016). Vacuum powered suction devices tend to be more efficient than sweep nets, due to the consistency, ease of use, and the ability to capture many arthropods at a time (Buffington and Redak 1998). There are different types of vacuum devices, each utilizing a different power source (Thomas 2012). Gas powered vacuums, G-Vac and D-Vac, collect more specimens than nets and electric powered vacuums (E-Vac); however, these devices are typically heavier and louder than their electrical counterparts. Gas powered vacuums do not typically benefit from increased nozzle size, unless the suction power of the device is also increased (Bell et al. 2000). These techniques do not also benefit from increased sampling duration, unless the sampling area has variable vegetation and terrain (Bell et al. 2000). G-Vacs can be more efficient sampling arthropod populations in terrestrial ecosystems than pitfall traps and sweep nets (Samu and Sárospataki 1995). A common vacuum used for terrestrial arthropod sampling is the D-Vac, a large, backpack mounted, gas powered vacuum device with a variety of attachments and modifications capable of changing the suction nozzle diameter (Dietrick 1961). The D-Vac is an effective technique for collecting arthropods in order to measure the species richness of terrestrial ecosystems (Elliot et al. 2006). D-Vacs and G-Vacs have been compared in previous studies (Wilson et al. 1998); the G-Vac can be as efficient a sampling device as the D-Vac, at a lower cost and greater convenience (Macleod et al.1994). Different sampling techniques have

been shown to capture different species and different-sized arthropods (Doxon et al. 2010). Using the appropriate sampling method to capture arthropods is an important factor to consider, since not all techniques are capable of sampling every aspect of an ecosystem (Sanders and Entling 2011). The four different collecting methods used in this experiment to sample hemipteran species in a freshwater marsh included three types of vacuum and one sweep method.

Hemiptera

Hemiptera refers to the order of insects known as “true bugs”. They have haustellate mouthparts that are used for the extraction of fluids from plants or prey. Hemipteran insects have a large impact on plant communities. Many of these insect species impact plant communities through direct feeding on plants or transmission of diseases (Dietrich 2005). Auchenorrhyncha, the suborder of Hemiptera that includes leafhoppers, planthoppers, and treehoppers have a major impact on the growth and competition of plants within any community through the extraction of fluids from phloem, xylem, and mesophyll (Connacher 2012).

Sampling Hemipterans in Prairies

Grassland communities include numerous hemipteran species whose abundance and species richness are influenced by fire and herbivore grazing (Connacher 2012). In order to accurately sample an insect community, a variety of techniques should be used (Stewart and Wright 1995). Suction devices and pitfall traps are often used to sample arthropods living near the ground. Typical suction devices used in grasslands include gas powered vacuums, such as the D-Vac (Borges and Brown 2003). The height of plants in a grassland community can affect the efficiency of vacuum devices (Hossain et al.1999). Greater time is often required to thoroughly sample these communities for species of insects, due to the compressing of plants while sampling (Brook et al. 2008). Utilization of the D-Vac and sweep netting techniques has been

shown to be efficient at sampling grassland phytophagous hemipteran species, as well as accurately representing their biodiversity within a grassland (Standen 2000).

Sampling Hemipterans in Wetlands

Wetlands are transitional communities between terrestrial and aquatic communities in which the soil is periodically inundated and water loving plants, hydrophytes, are dominant (Nelson 2010). The species diversity of plant communities is affected by the distribution and availabilities of nutrients such as nitrogen, potassium, and phosphorous (Mitsch and Gosselink 2007). If the hydrology in an area is altered, it directly affects the composition of the entire community (Wassen et al. 2001). Freshwater marshes are characterized by the dominance of herbaceous plants and sparse tree cover (Nelson 2010). Water level and hydroperiod in marshes are heavily influenced by flooding and large fluctuations of water input into the ecosystem (Junk et al. 1989). The fluctuation and hydroperiod of wetlands has been associated with fluctuations in wetland insect emergence and population size (Lundström et al. 2014). Sampling hemipteran species in a marsh is an effective way to monitor ecosystem health, since insects fill many crucial niches within wetland communities (Gernes and Helgen 2002).

Common methods of sampling wetland macroinvertebrate populations include sweep nets, box enclosures, and stationary traps (Lowe et al. 2016). Sampling techniques used in prairies can often be utilized for sampling emergent marsh plants and as well as grasslands since both habitatas are dominated by herbaceous plants. G-Vacs have shown to be more efficient than net based techniques when sampling aquatic macrophytes for certain hemipteran species (Wilson et al. 1998). Vacuum-based techniques were chosen for this study because the literature pertaining to the effectiveness of these techniques in a freshwater marsh is sparse.

Objectives of Study

The objectives of this study were: 1) to establish a species list of hemipteran species present in the marsh at Van Meter State Park; 2) to determine if there were differences in species richness, evenness, and diversity among four sampling techniques; and 3) to determine if there were differences among the sampling months and sampling techniques.

CHAPTER 2
METHODS AND MATERIALS

Study Site

Located in Saline County, Missouri, Van Meter State Park is situated in the western portion of the glaciated plains of central Missouri (Thom 1985). Old growth mesic forests, a sharp and pronounced ridge referred to as Devil's Backbone, and loess hills are prominent features (Thom 1985). Along with the loess hills, the area features one of Missouri's remaining freshwater marshes that has existed since pre-settlement times (Flader 1992). Hemipteran populations were sampled in the freshwater marsh area of the park.

Sampling Techniques

Four sampling methods were compared. The D-Vac® model 24 consists of a gasoline powered engine mounted on a metal backpack frame. It is powered by a Briggs & Stratton 3.75 horsepower engine and is capable of achieving suction power of 60.9 m^3/min. The D-Vac weighs 15.9 kg. A 203.2 cm long hose connects the engine to the 31.7 cm diameter opening (Rincon-Vitova Insectaries 2001). The other gasoline powered suction device was a G-Vac, or gasoline powered vacuum. The Poulan Pro Leaf Blower/Vacuum ® is a gasoline powered device capable of reaching a suction power of 12.2 m^3/min. The vacuum has a suction nozzle of 12.7cm. The vacuum weighs 6.8 kg. The third suction device was an electric powered leaf blower and vacuum (E-Vac). The Black & Decker Cordless Sweeper Vac® , Model # LSWV36 weighs 2.5 kg, and can reach a suction power of 2.4 m^3/min, and is powered by a lithium ion 36V battery. The final sampling method used was a 30.5 cm diameter BioQuip® sweep net.

Methods

Sampling sites were determined by scouting areas in the freshwater marsh in April 2015, a month prior to the first sampling date. Transect locations were selected based upon differing aquatic macrophyte communities to ensure that all herbaceous plants in the marsh were sampled. The plant communities primarily consisted of sedge and grass species. The most dominant plant within these communities was the sedge *Carex hyalinolepis* (Cyperaceae) (Shields 2017). After determining the appropriate location to sample, transects and plots were established. Three linear transects were established in representative plant communities (Fig.1). Three random numbers were derived from a random number table six times per transect, which determined the location of the plots.The selected numbers represented the distance walked in meters, along the transect in which the two sample plots were established and the distance traveled, in meters, from the transect in which each sampling plot would be placed. Points were marked with yellow field flags. This process was repeated for two other established transects, yielding a total of 36 sampling plots within all three transects.

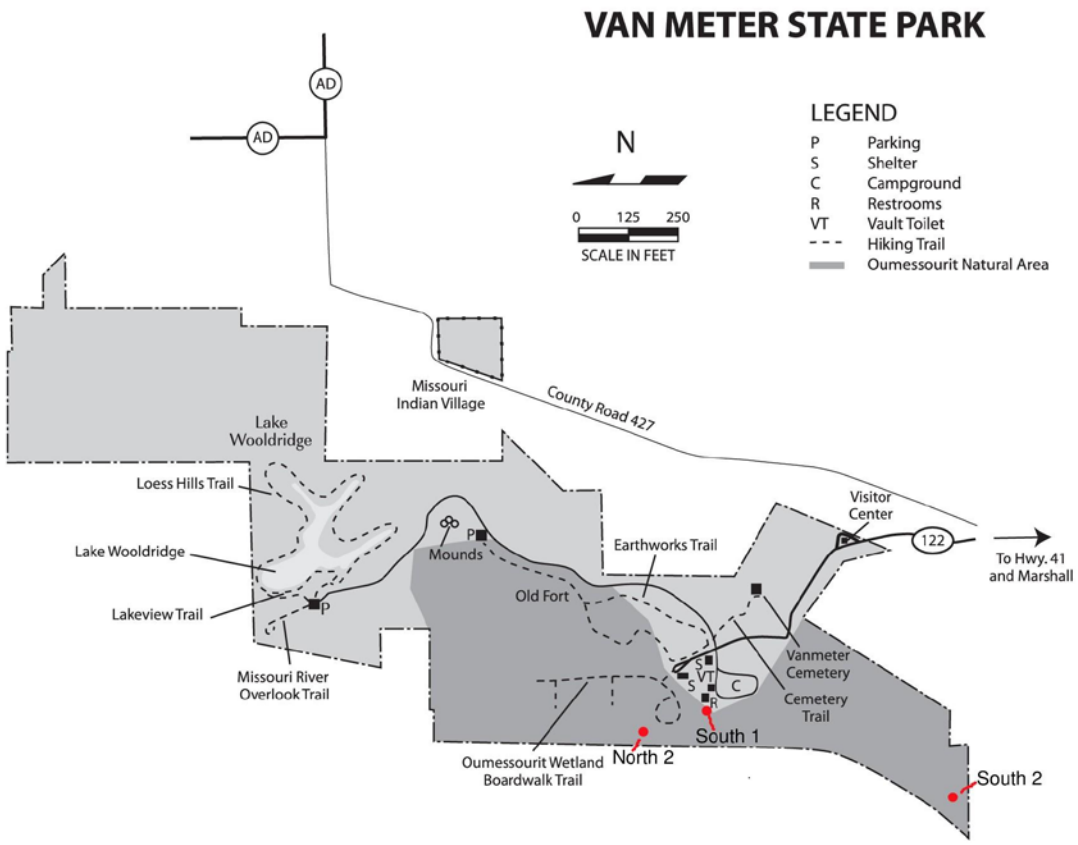

Figure 1. The location of the three established transects (North 2, South 1, and South 2) within the freshwater marsh (retrieved from https://mostateparks.com/park/van-meter-state-park).

Each plot within a transect was sampled using one of the four collecting methods. Data cards had the following information: collecting date, location of the plot, and collecting method. RPG Roller, a dice rolling phone application, was used to determine which method was used at a plot. Each collecting technique was assigned a number between one and four. A four sided die was rolled on the app for each plot. Each technique was used a total of three times per transect. After determining this, the card was inserted into a 1 gallon Ziploc storage bag.

When sampling a plot, the selected collecting technique was used in accordance with what the card indicated. An alcohol swab was placed into the bag in order to euthanize collected

insects. Plot dimensions were $1m^2$, indicated by a pvc pipe quadrat placed prior to sampling. The plots eliminated potential for Peripheral Suction Effect (PSE), which refers to the potential of sampling an undesired area while using a vacuum-based sampling technique (Cherrill 2015). Sampling each $1m^2$ plot involved vacuuming for 30 seconds, or taking 20 sweeps with the sweep net . Collected insects were inserted into the appropriately labeled Ziploc bag, which was placed in a cooler containing "blue ice" and freezer packs. Coolers were transported to the University of Central Missouri where samples were stored in a freezer. Insects were collected on 13 June, 25 July, and 12 September 2015.

In the lab, each bag containing a sample from a designated plot was emptied into a pan of 70% isopropyl alcohol. Hemipterans (Heteroptera and Auchenorrhyncha) were separated from non-hemipterans and placed into vials containing 70% isopropyl alcohol. Adults were pinned and nymphs placed in vials containing 70% isopropyl alcohol. Specimen labels included: MO: Saline County, Van Meter State Park, date collected, plot location, and collecting method. Insects were identified to species using [Beamer (1946b; 1950a, b; 1951, 1955), Slater and Baranowski (1978), Flynn and Kramer (1983), Bartlett and Deitz (2000), Dietrich (2005), Bartlett et al. (2014), Halbert et al. (2014), and Bugguide.net]. Total number of each species and stage of development were tallied on a spreadsheet on Google Drive. Due to the difficulty of identifying some species of Cicadellidae, some specimens are identified as morphospecies.

Due to the large differences in species numbers (Table 1), the total number of each species was square root transformed prior to running any multivariate analyses.The number of hemipterans collected from the plots in each transect per technique were combined in order to decrease the statistical noise. After the data were transformed, a Bray Curtis similarity matrix was created to rank the data according to the similarity between samples.

The statistical program PRIMER-E, was used to perform the statistical analyses (Clarke and Gorley 2015). The Bray Curtis method ranks and organizes data based on abundance and richness, dissimilarity, and the contribution of dissimilarity to the sample (Bray and Curtis 1957). A Two Way Analysis of Similarity (ANOSIM) was used to test if there was a significant difference among the sampling months and sampling techniques (Clarke 1993). ANOSIM establishes a table based on a set number of possible permutations, which represents the number of possible interactions with actual interactions to calculate the derived statistical value, represented as the R-Value, and the associated *P*-value (Clarke 1993). The level of significance for this study was 0.05. Nonmetric multidimensional scaling (NMDS) was used to illustrate similarities derived from the ANOSIM between sampling months and sampling techniques (Kruskal 1964). A Similarity Percentage Analysis (SIMPER) was used to test for similarity in species abundances for the sampling months and sampling techniques. Average abundance for each species was used to determine average dissimilarity and dissimilarity percentage between samples. Dissimilarity represents the statistical difference a species contributes to the sample based off of the average abundance. A larger dissimilarity value represents a species that is driving the statistical difference between techniques. The Shannon-Weiner diversity index was used to measure species diversity and evenness ($H^1 = -\sum[(Pi)*ln(\text{Pi})]$ where H^1= the Shannon Wiener value, and Pi= the total number of species (Krebs 2014). The Simpson's diversity index was used to measure the diversity and dominance of the transects and techniques ($D = \sum [n / N]^2$), Where D = the Simpson Diversity value, n = the total number of a particular species, and N = the total number of all species (Krebs 2014).

CHAPTER 3
RESULTS

There was a noticeable difference in the number of individuals per species collected (Appendix 1). The most numerous species was *Megamelus bifidus* (Beamer) (1096), followed by *Cedusa obscura* (Ball) (321), and *Stenocranus delicatus* (Beamer) (216). Species were ranked in descending order of their abundance and graphed. In order to accurately represent the difference in the number of each species collected among all sampling dates, the data were transformed by taking the LOG 10 of the total number of individuals collected per species (Figure 2).

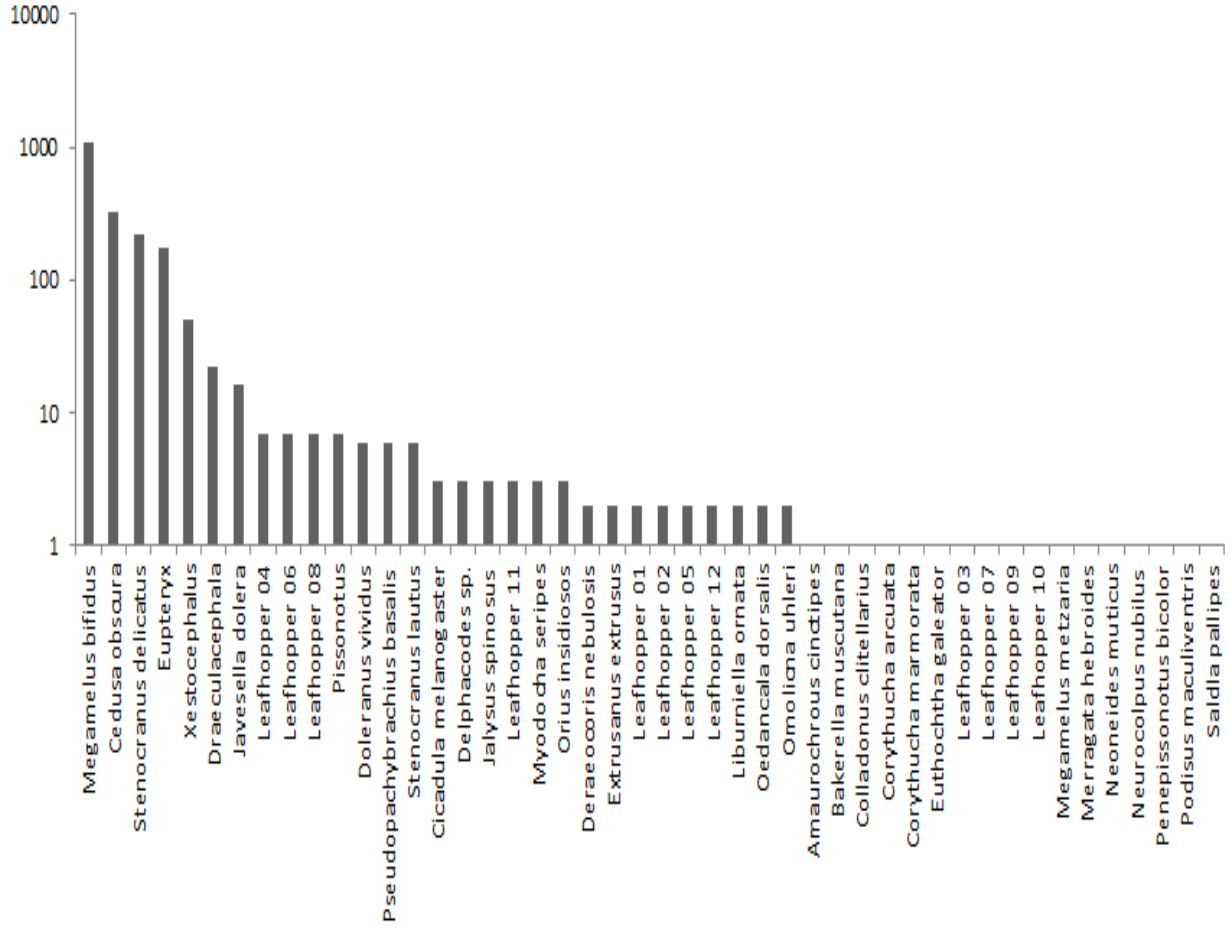

Figure 2. The total number of individuals (log base 10) per species collected.

A total of 1996 Auchenorrhyncha and Heteroptera specimens were collected and identified. The D-Vac had the highest number of hemipterans collected in each of the three months with values of 269 in June, 101 in July, and 645 in September. The G-Vac had the second highest abundance with values of 201 in June, 26 in July, and 443 in September. The E-Vac had the third highest values of 61 in June, 5 in July, and 214 in September. The sweep net had the lowest number of insects collected with values of 15 in June, 3 in July, and 13 in September (Figure 3). Total percentages of identified hemipterans per technique include the D-Vac with 51%, the G-Vac with 34%, the E-Vac with 14%, and the sweep net with 1% (Figure 4).

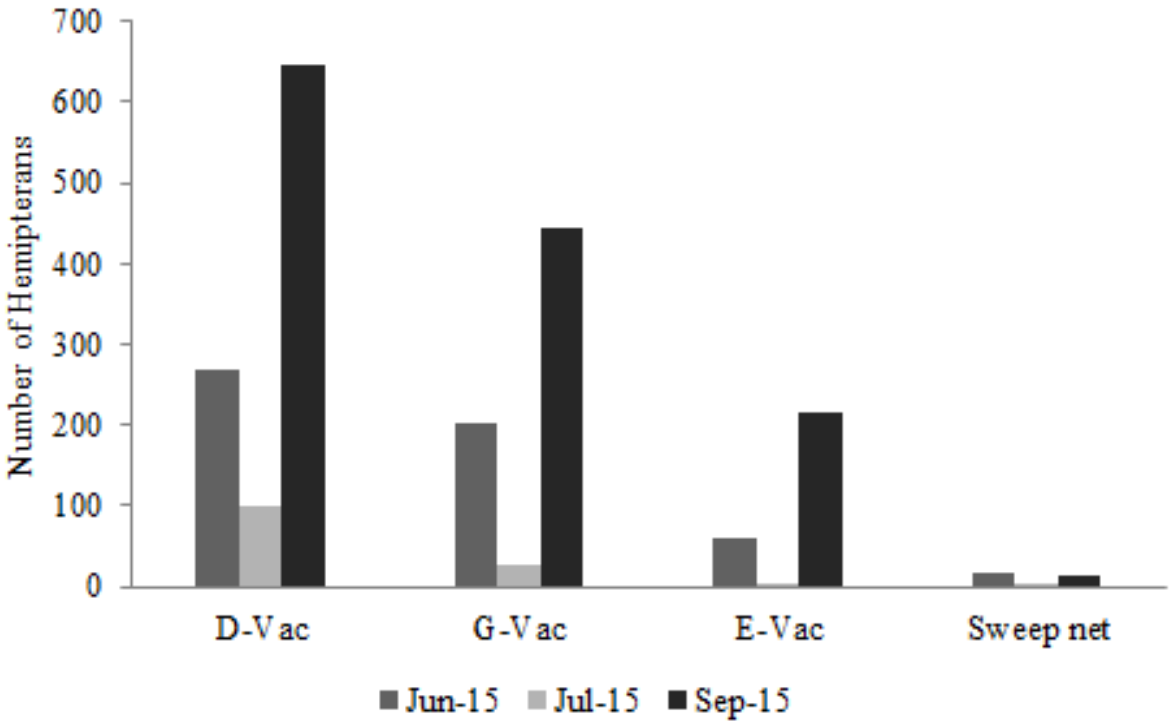

Figure 3. Number of hemipterans collected per month by each sampling method.

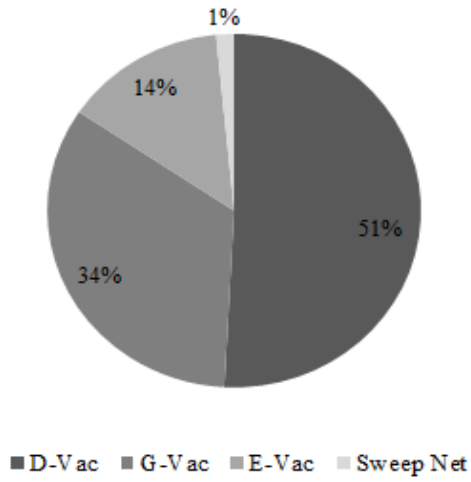

Figure 4. Percentage of hemipterans collected by each sampling method.

The three most abundant species sampled include *Megamelus bifidus, Cedusa obscura , and Stenocranus delicatus* (Figure 2). The diameter of the vacuum nozzle and the suction power of the device influenced the number of hemipterans collected, as well as the number of species collected. A total of 1113 hemipterans was collected with the D-Vac's 31.7 cm nozzle and 60.9 m^3/min , 742 with the G-Vac's 12.7 cm nozzle and 12.2 m^3/min, and 274 with the E-Vac's 8.3 cm nozzle and 2.4 m^3/min (Figure 5).

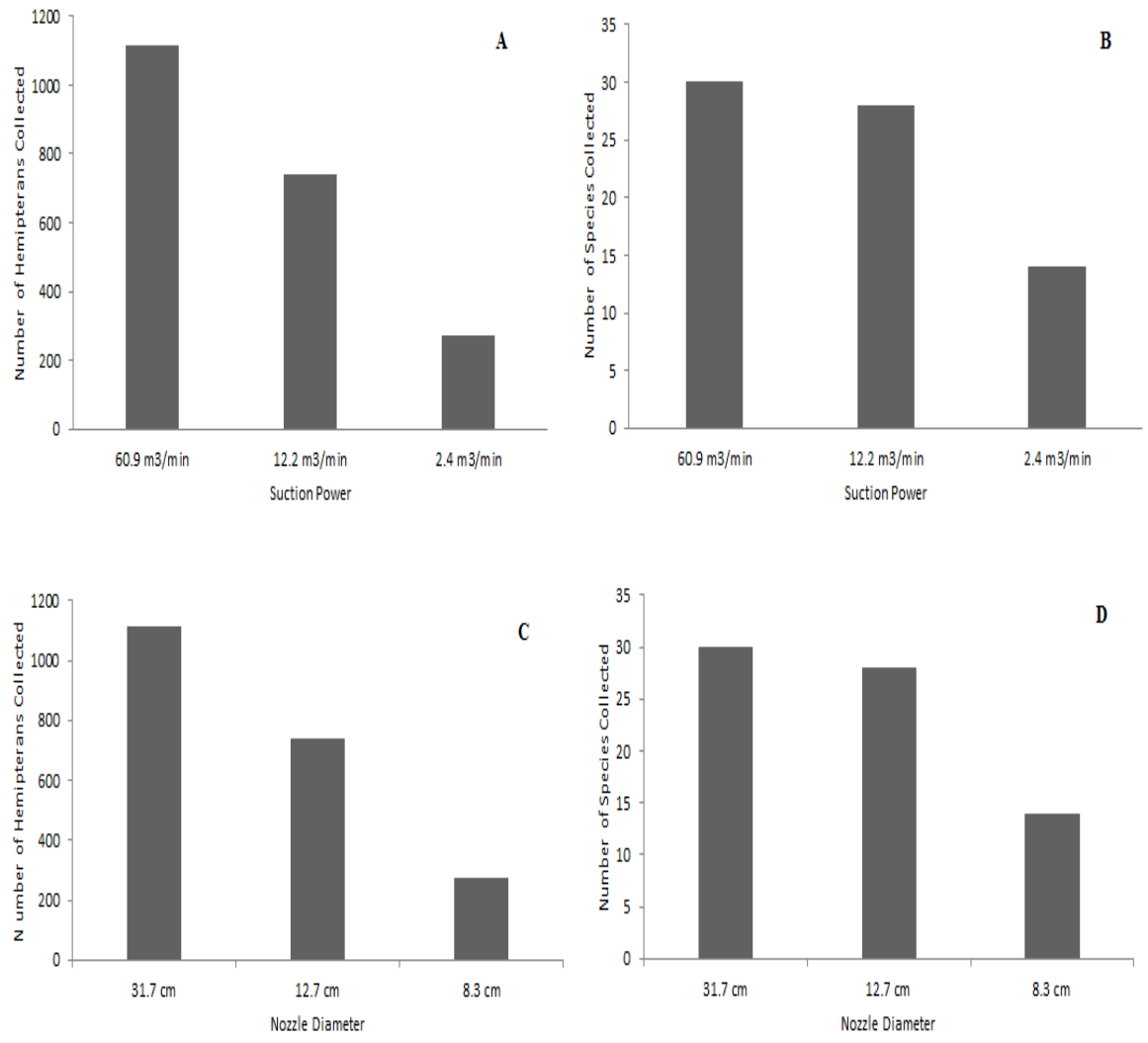

Figure 5. Number of individuals and species of Hemiptera collected related to suction power and nozzle diameter.

A total of 47 species of insects was identified to species or morphospecies. The D-Vac collected a total of 30 species, the G-Vac collected 28, the E-Vac collected 14, and the sweep net collected 7 (Figure 6). Each sampling method collected species that were only sampled with that technique, referred to as “unique species”. The D-Vac collected 15 unique species, the G-Vac collected 14, the E-Vac collected 3, and the sweep net collected 0 (Figure 7). Each technique had

species overlap with another technique, indicating that some techniques captured the same species as another technique.

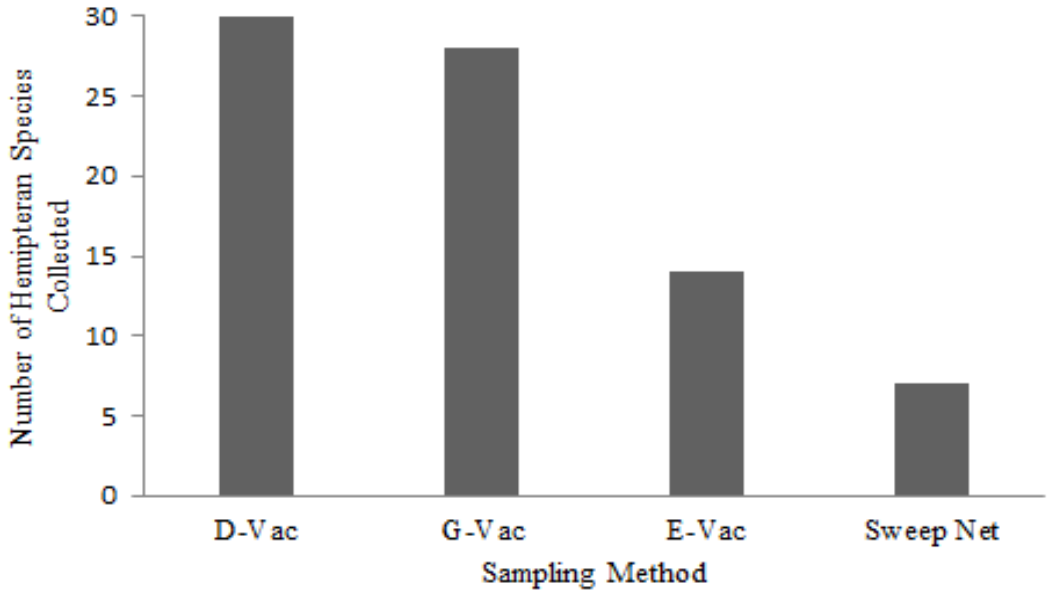

Figure 6. Total number of hemipteran species collected per sampling method.

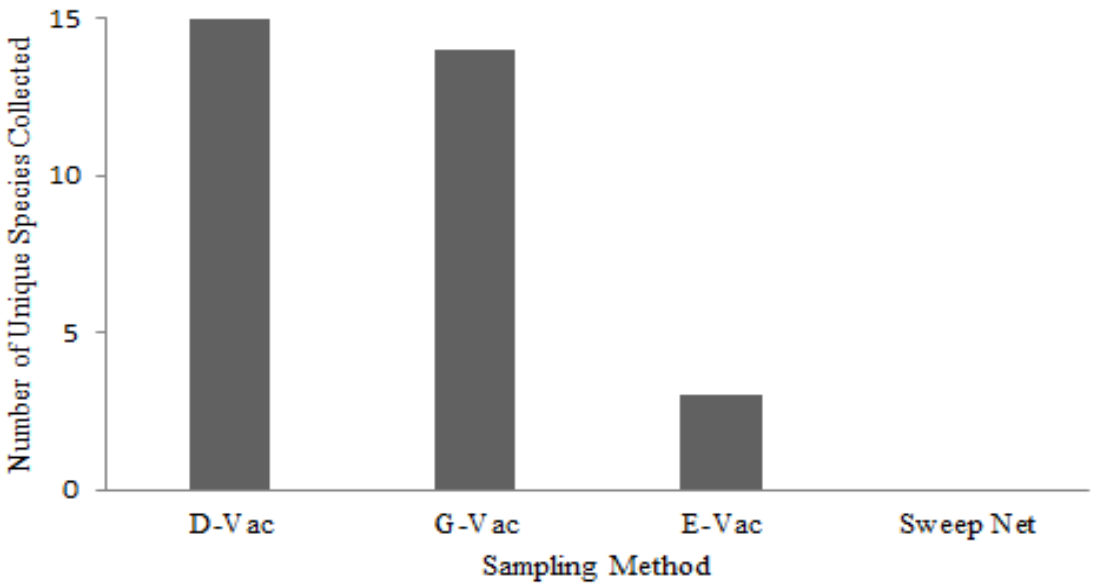

Figure 7. Number of unique species (species only collected with one technique) collected per sampling method.

The D-Vac and G-Vac had an overlap of 14 species. The D-Vac and E-Vac had an overlap of 11 species. The D-Vac and sweep net had an overlap of 7 species. The G-Vac and E-Vac had an overlap of 11 species. The G-Vac and sweep net had an overlap of 7 species. The E-Vac and sweep net had an overlap of 6 species (Table 1).

Table 1. Number of shared species among techniques.

Sampling Technique	D-Vac	G-Vac	E-Vac	Sweeping
D-Vac	15	14	11	7
G-Vac	14	14	11	7
E-Vac	11	11	3	6
Sweeping	7	7	6	0

The Shannon-Wiener Diversity Index value for the total diversity of the hemipteran community equalled 1.78 with an evenness value of 0.46. The diversity value for the D-Vac was 1.63 and an evenness value of 0.47. For the G-Vac, the diversity value was 1.45 with an evenness of 0.44. The E-Vac had a diversity value of 0.92 and an evenness value of 0.35. The sweep net had a diversity value of 0.40 and an evenness value of 0.20. The Simpson Diversity Index value for the transects was 0.34. The D-Vac had a Simpson diversity value of 0.29, the G-Vac had a value of 0.41, the E-Vac had a value of 0.61, and the sweep net had a value of 0.23 (Table 2).

Table 2. Diversity indices among techniques.

Sampling Technique	Shannon Diversity Index	Species Evenness	Simpson Diversity Index
D-Vac	1.63	0.42	0.29
G-Vac	1.45	0.38	0.41
E-Vac	0.92	0.24	0.61
Sweep Net	0.40	0.10	0.23
Total Diversity	1.78	0.46	0.34

Statistical Analyses

The Two Way ANOSIM yielded a significant difference in hemipteran abundances among all sampling months (Global R = 0.408; *P* = 0.001) (Table 3). The differences among sampling months was illustrated using NMDS (Figure 8). The Two Way ANOSIM indicated that there was a significant difference in hemipteran abundances among sampling techniques (Global R = 0.241, and *P* = 0.003) (Table 4). The difference among sampling techniques was illustrated using NMDS (Figure 9). Pairwise tests revealed a significant difference in hemipterans collected between the D-Vac and E-Vac (R value = 0.397, *P* = 0.031) (Table 4), and the D-Vac and sweep net (R = 0.298, *P* = 0.029) (Table 4).

Table 3. Two Way ANOSIM for the sampling months

Global Test
Sample statistic (Global R): 0.408
Significance level of sample statistic: 0.05

Pairwise tests

Groups	R Statistic	P-Value	Possible Permutations	Actual Permutations	Number >= Observed
June, July	0.525	0.002	10000	999	1
June, Sept	0.329	0.02	10000	999	19
July, Sept	0.406	0.004	10000	999	3

Table 4. Two Way ANOSIM for the sampling methods.

Global Test
Sample statistic (Global R): 0.241
Significance level of sample statistic: 0.05

Pairwise tests

Groups	R Statistic	P-Value	Possible Permutations	Actual Permutations	Number >= Observed
Dvac, Gvac	0.086	0.261	1000	999	260
Dvac, Evac	0.397	0.031	1000	999	30
Dvac, Sweep	0.298	0.029	1000	999	28
Gvac, Evac	-0.017	0.485	1000	999	484
Gvac, Sweep	0.15	0.165	1000	999	164
Evac, Sweep	0.137	0.12	300	300	36

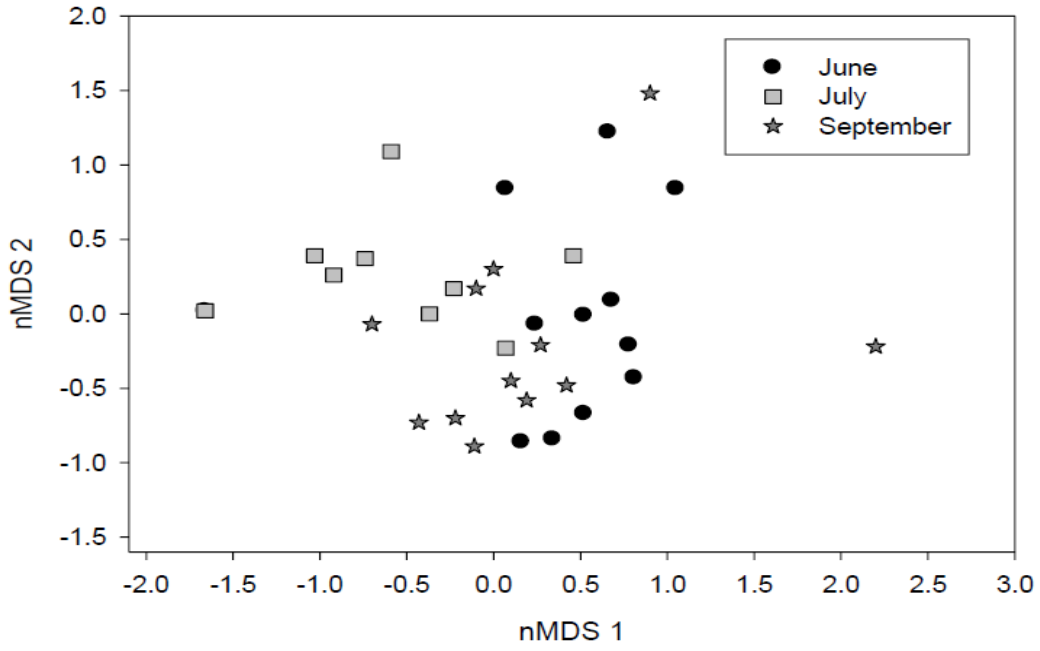

Figure 8. NMDS graph depicting relationships among sampling months in number of Hemiptera collected.

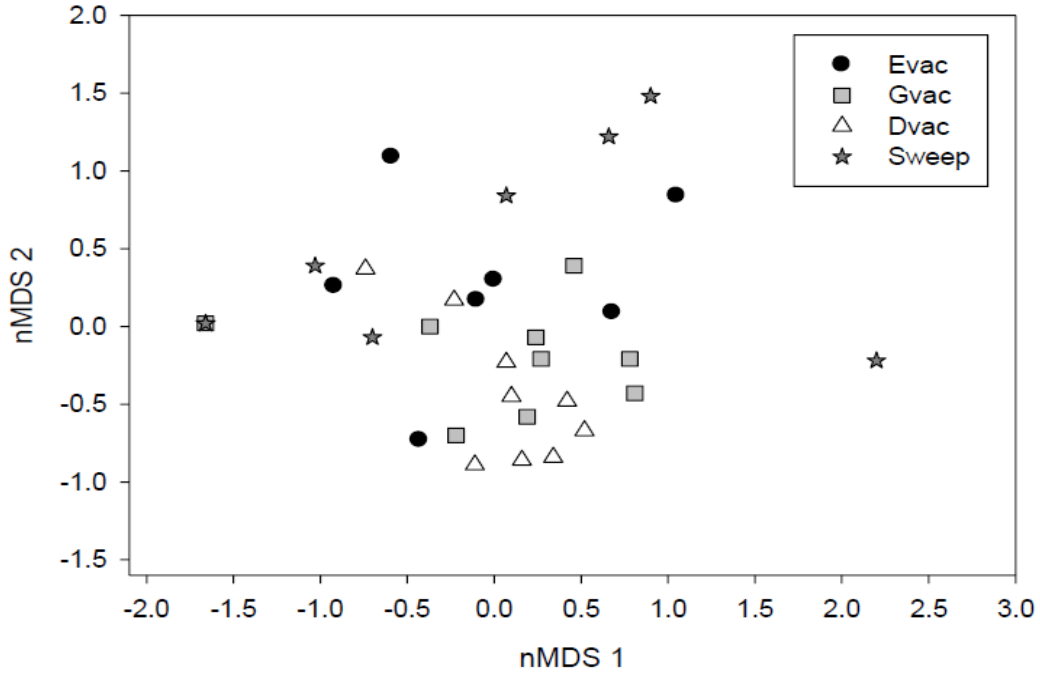

Figure 9. NMDS graph depicting the relationships among sampling techniques in number of Hemiptera collected.

CHAPTER 4
DISCUSSION

The D-Vac was the most effective device for sampling hemipterans in the marsh. While the D-Vac sampled greater numbers of hemipterans than the other techniques it had many disadvantages. Its weight (15.9 kg) makes it physically demanding to haul when sampling. Another disadvantage was difficulty in starting the device which greatly extended time spent in the field. The D-Vac is also the most expensive of the suction devices ($2800) which may be a deterrent for many collectors. The G-Vac, with the second highest counts, has the potential to be as efficient at sampling as the D-Vac. Both devices have adequate suction power, the G-Vac is lighter (6.8 kg), but is limited by its smaller tube diameter of 12.7 cm. If a larger suction orifice could be attached to the G-Vac, more specimens could have been collected.

The E-Vac collected fewer hemipterans than the D-Vac or G-Vac but much more than sweeping. The main advantage of this device is its weight, 2.5 kg. This weight makes it convenient to use and transport. Its low suction power (2.4 m^3/min) and smaller tube (8.3 cm) limits its ability to sample tall vegetation, thus reducing its capacity to collect large numbers of insects. This vacuum seems to be better suited for sampling individual plants, not large plots, due to its smaller tube size and lower suction power of. The sweep net was the least efficient sampling device and is not efficient for collecting large numbers of small hemipterans but is suited for catching larger specimens. Another difficulty of sweep netting is the density of plants being sampled and the inability of the net to reach the lower strata of the plant communities.

The D-Vac and G-Vac had similar sampling effectiveness. While the D-Vac had the highest Shannon-Wiener Diversity value (1.63), it had the second lowest Simpson value (0.29). The G-Vac had the second highest Shannon-Wiener Diversity value (1.45), and the second highest Simpson value (0.41). The Simpson Diversity equation puts a larger emphasis on

dominant species (Krebs 2014). Since the D-Vac collected the largest number of two of the most numerous species (*M. bifidus* [461], *C. obscura* [258]), this could have reduced this method's Simpson's Diversity value. The D-Vac captured the most individuals of a species and unique species (30 and 15) while the G-Vac captured the second highest number of species and unique species (28 and 14). Similar results were found in Wilson et al. (1998), and Macleod et al. (1994), suggesting that that the G-Vac can be as efficient as the D-Vac for sampling marsh hemipteran species, with fewer disadvantages. The E-Vac had the largest Simpson Diversity index (0.61). This is most likely due to having fewer individuals of the most dominant species collected by the other sampling methods while capturing many representatives of other species, which potentially skewed the Simpson's index. The vacuum techniques were efficient at sampling wetland Hemiptera, specifically Auchenorrhyncha, supporting the findings of previous prairie studies (Standen 2000). This suggests that some of the vacuum techniques used in prairie sampling can be used with similar effectiveness within a freshwater marsh.

September had the largest number of collected insects, followed by June, with July having the fewest number of insects sampled. This suggests that July is a month in between generations of hemipteran populations within the marsh, due to the large number of adult species collected in June and September. The vacuum based techniques showed similar effectiveness Each sampling technique has different advantages. When sampling insect populations, a variety of techniques should be utilized to effectively sample any community (Stewart 2002).

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APPENDIX A
NUMBER OF INDIVIDUALS COLLECTED PER SPECIES AND TECHNIQUE

Taxon	D-Vac	G-Vac	E-Vac	Sweeping	Total
Auchenorrhyncha					
Cicadellidae					
Cicadula melanogaster (Provancher)	2	1	0	0	3
Colladonus clitellarius (Say)	0	1	0	0	1
Doleranus sp.	1	1	4	0	6
Draeculacephala sp.	12	6	1	3	22
Eupteryx sp.	124	47	4	1	176
Extrusanus extrusus (Van Duzee)	2	0	0	0	2
Leafhopper 01	2	0	0	0	2
Leafhopper 02	2	0	0	0	2
Leafhopper 03	0	1	0	0	1
Leafhopper 04	7	0	0	0	7
Leafhopper 05	2	0	0	0	2
Leafhopper 06	3	1	2	1	7
Leafhopper 07	0	0	1	0	1
Leafhopper 08	7	0	0	0	7
Leafhopper 09	0	1	0	0	1
Leafhopper 10	1	0	0	0	1
Leafhopper 11	1	1	1	0	3
Leafhopper 12	1	0	1	0	2
Xestocephalus(Van Duzee)	25	22	3	0	50
Delphacidae					
Bakerella muscotana Beamer	0	1	0	0	1
Delphacodes sp	0	3	0	0	3
Javesella dolera (Spooner)	1	14	1	0	16
Liburniella ornata (Stål)	2	0	0	0	2
Megamelus bifidus Beamer	461	412	217	6	1096
Megamelus metzaria Crawford	0	1	0	0	1
Penepissonotus bicolor Beamer	0	1	0	0	1
Pissonotus sp.	1	0	0	0	1
Pissonotus piceus (Van Duzee)	6	0	0	0	6
Stenocranus delicatus Beamer	80	95	29	12	216
Stenocranus lautus Van Duzee	1	5	0	0	6

Taxon	D-Vac	G-Vac	E-Vac	Sweeping	Total
Derbidae					
Cedusa obscura (Ball)	257	43	14	7	321
Omolicna uhleri (Ball)	2	0	0	0	2
Heteroptera					
Acanthocoridae					
Orius insidiosus (Say)	0	3	0	0	3
Berytidae					
Jalysus spinosus (Say)	0	3	0	0	3
Neoneides muticus (Say)	1	0	0	0	1
Coreidae					
Euthochtha galeator (Fabricius)	0	1	0	0	1
Hebridae					
Merragata hebroides (White)	0	0	1	0	1
Miridae					
Deraeocoris nebulosis (Uhler)	1	1	0	0	2
Neurocolpus nubilus (Say)	1	0	0	0	1
Pentatomidae					
Amaurochrous cinctipes (Say)	0	0	1	0	1
Podisus maculiventris (Say)	0	1	0	0	1
Pachygronthidae					
Oedancala dorsalis (Say)	2	0	0	0	2
Rhyparochromidae					
Pseudopachybrachius basalis (Dallas)	4	1	0	1	6
Myodocha seripes (Oliver)	2	1	0	0	3
Saldidae					
Saldula pallipes (Fabricius)	1	0	0	0	1
Tingidae					
Corythucha arcuata (Say)	0	1	0	0	1
Corythucha marmorata (Uhler)	0	1	0	0	1
Totals	1015	670	280	31	1996
Percent	51.0	34.0	14.0	2.0	

APPENDIX B
SIMILARITY PROFILE FOR D-VAC AND E-VAC COMPARISON

Groups Dvac & Evac

Average dissimilarity = 68.43

Species	Av.Abund (D-Vac)	Av.Abund (E-Vac)	Av.Diss	Diss/SD	Contr.%	Cum.%
Megamelus bifidus	4.9	2.95	11.29	±0.88	16.51	16.51
Cedusa obscura	4.25	0.73	10.9	±1.21	15.92	32.43
Eupteryx sp.	2.33	0.25	5.87	±1.00	8.59	41.02
Stenocranus delicatus	1.78	1.22	5.72	±1.57	8.36	49.38
Megamelus bifidus nymphs	1.92	1.45	3.65	±0.89	5.33	54.71
Xestocephalus	1.26	0.3	3.10	±0.77	4.54	59.25
Stenocranus delicatus nymphs	0.68	0.55	2.93	±0.9	4.29	63.53
Cicadellidae nymphs	1.06	0.38	2.45	±1.04	3.58	67.11
Cedusa obscura nymphs	0.65	0.38	1.62	±0.65	2.37	69.48
Javesella dolera	0.11	0.18	1.58	±0.43	2.31	71.79
Leafhopper 7	0.41	0	1.37	±0.44	2.00	73.79
Miridae nymph	0.54	0.38	1.34	±0.47	1.96	75.76
Cicadula melanogaster	0.22	0	1.34	±0.38	1.96	77.71
Draeculacephala sp.	0.63	0.13	1.10	±0.64	1.60	79.32
Pseudopachybrachius basalis	0.31	0	0.99	±0.47	1.45	80.76
Pentatomidae nymphs	0.29	0.13	0.91	±0.54	1.33	82.09
Leafhopper 12	0.38	0	0.88	±0.55	1.29	83.38
Doleranus vividus	0.11	0.25	0.86	±0.54	1.25	84.63
Leafhopper 10	0.27	0.25	0.82	±0.72	1.20	85.84
Mis. nymph	0.37	0	0.72	±0.37	1.06	86.9
Dedancala dorsalis	0.22	0	0.71	±0.56	1.04	87.93
Leafhopper *5*	0.22	0	0.65	±0.56	0.95	88.88
Mjodoclia scrinipes	0.22	0	0.61	±0.44	0.89	89.77
Pissonotus piceus	0.27	0	0.54	±0.37	0.78	90.55

APPENDIX C
SIMILARITY PROFILE FOR D-VAC AND SWEEP NET COMPARISON

Average dissimilarity = 86.21

D-vac/Sweep net

Species	Av.Abund (D-Vac)	Av.Abund (sweep)	Av.Diss	Diss/SD	Contrib%	Cum%
Megamelus bifidus	4.90	0.52	16.33	±1.07	18.94	18.94
Cedusa obscura	4.25	0.63	13.23	±1.31	15.34	34.28
Eupteryx sp.	2.33	0.13	7.43	±1.03	8.62	42.90
Stenocranus delicatus	1.78	0.65	7.37	±1.44	8.55	51.45
Megamelus bifidus nymphs	1.92	0	5.57	±0.9	6.46	57.92
Xestocephalus	1.26	0	4.98	±0.77	5.77	63.69
Cicadellidae nymphs	1.06	0	3.55	±0.97	4.12	67.81
Stenocranus delicatus nymphs	0.68	0	2.52	±0.55	2.93	70.73
Miridae nymph	0.54	0	2.31	±0.46	2.68	73.42
Cedusa obscura nymphs	0.65	0	2.26	±0.61	2.63	76.04
Leafhopper 7	0.41	0	1.56	±0.46	1.81	77.85
Cicadula melanogaster	0.22	0	1.55	±0.39	1.79	79.65
Draeculacephala sp.	0.63	0.22	1.33	±0.65	1.55	81.2
Pseudopachybrachius basalis	0.31	0.13	1.31	±0.56	1.52	82.71
Javesella dolera	0.11	0	1.16	±0.29	1.34	84.06
Leafhopper 12	0.38	0	1.12	±0.55	1.30	85.36
Oedancala dorsalis	0.22	0	0.94	±0.56	1.09	86.44
Mis. nymph	0.37	0	0.90	±0.37	1.04	87.48
Leafhopper 5	0.22	0	0.86	±0.56	1.00	88.48
Pentatomidae nymphs	0.29	0	0.72	±0.37	0.83	89.31
Myodocha seripes	0.22	0	0.68	±0.46	0.79	90.10