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Topographic Factors Affecting the Tree Species Composition of Forests in the Upper Piedmont of Virginia

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ABSTRACT

There are many factors that influence forest species composition and many are linked to topographical features. This study, conducted on the Ferrum College campus in the Upper Piedmont Physiographic Province of Virginia revealed three major forest types associated with topographic factors using cluster analysis and detrended correspondence analysis. The first type of forest occurred mostly on northeastern slopes on toe slope topographic positions and was mainly composed of tulip tree (*Liriodendron tulipifera*) and red maple (*Acer rubrum*). The second type of forest was found on shoulder and side slope positions and was composed mostly of high densities of sourwood (*Oxydendrum arboreum*), red maple and chestnut oak (*Quercus prinus*) species. The final forest type was located mostly on ridgetops and shoulder slope positions with a southwestern aspect and was composed mostly of white pine (*Pinus strobus*), sourwood, chestnut oak and scarlet oak (*Quercus coccinea*). In general, tree density increased with ascending slope position while DBH decreased. Species richness did not differ significantly by topographic position or aspect.

INTRODUCTION

There are many variables that influence forest species composition including soil moisture and nutrients, air temperature, light and disturbance regime. These variables are often strongly linked to topographic features such as aspect, slope position, inclination and elevation (Desta et al. 2004). Edaphic and topographic factors exert important influences along the upper Piedmont and Blue Ridge physiographic provinces of Virginia (Stephenson 1982, Harrison et al. 1989, Farrell and Ware 1991, Copenheaver et al. 2006). These forests, however, also have a long and complex disturbance history that has affected forest species composition.

The forests in this region of Virginia were once dominated by American chestnut (*Castanea dentata*) until the invasion of the chestnut blight fungus (*Endothia parasitica*) in the 1920s (Johnson and Ware 1982). Following this event, highest rankings of density and basal area have been shared by a number of tree species,

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predominately oaks (*Quercus*) and hickories (*Carya*) (Johnson and Ware 1982). A wide range of other natural and anthropogenic factors including recent ice storms (Stueve et al. 2007) and gypsy moth defoliation (Whitmire and Tobin 2006) also influence the species composition of Appalachian and Piedmont forests in Virginia. In addition, selective logging, deer browsing and the spread of invasive plant species, particularly ailanthus (*Ailanthus altissima*), continue to impact the structure and composition of these forests (Carter and Fredericksen 2007).

This study characterized the species composition of the forests on the property of Ferrum College located on the Upper Piedmont Physiographic Province close to the Blue Ridge Escarpment in Franklin County, Virginia. Data were collected on topographic position and aspect in order to interpret the species composition in relation to topographic variables.

MATERIALS AND METHODS

During 2006 and 2007, 19 permanent plots were established in forested areas of the 700-acre Ferrum College campus (N 36.5°, W 80.1°). Plantation forests were not included in this study. Plots were 20 x 20 m in size and were initially established randomly from a topographical map. After selection of the first eight plots, however, an effort was made to select plot locations based on representation of possible aspect and slope position combinations, with each individual slope position and aspect being represented at least twice, except for northwest slope positions which had $n = 1$. The stands chosen for this study had not been subjected to recent logging; however, all of the stands had most likely been subjected to light selective logging during the 1970s, mostly for oak species and tulip tree (*Liriodendron tulipifera*). The elevation of the plots ranged from approximately 300-400 m.

Each tree in the plot with diameter at breast height (DBH) of $\geq$ 10cm was identified to species, tagged, and evaluated for crown class, crown condition, stem quality and stem condition. Each plot location was marked and recorded with a GPS mapping system, and aspect and slope position in the topography were recorded. Aspect was measured with a compass and slope position was categorically determined as ridge top, slope shoulder, side slope, toe slope, or valley bottom.

Average DBH, average basal area, average density and species richness were calculated by site according to aspect and also by slope position. Cluster analysis and detrended correspondence analysis (DCA) were used to determine similarities among plots with respect to species composition. Rare species were down-weighted in the analyses because they can exert an effect on ordinations that is disproportionate to their abundance. All ordination analyses were carried out using PC-ORD (Version 5, MJM Software, Gleneden Beach, Oregon). Kruskal-Wallis (K-W) non-parametric tests were conducted to determine if species richness, tree density, or mean tree diameter varied among slope position, aspect, or plot groupings generated by DCA and cluster analysis. Differences were considered statistically significant at $p \leq 0.05$. Analyses were carried out using SYSTAT 10.2 (SYSTAT Software, Inc., San Jose, CA).

RESULTS

The study plots contained 498 trees and 23 tree species. In these plots, the most abundant species were tulip tree, sourwood (*Oxydendrum arboreum*), and red maple

TABLE 1. Number of plots (N), average diameter at breast height (DBH), tree density, species richness, and top three most abundant species by topographic position in forested plots on the property of Ferrum College, Franklin County, VA. Means with the same letter are not significantly different at $p \leq 0.05$. LiTu = *Liriodendron tulipifera*, OxAr = *Oxydendrum arboreum*, AcRu = *Acer rubrum*, PiSt = *Pinus strobus*, QuPr = *Quercus prinus*, QuCo = *Quercus coccinea*, AiAl = *Ailanthus altissima*.

Topographic Position	N	DBH (cm)	Density (#/ha)	Species Richness	Most abundant species
Valley	2	33.7 a	238 b	3.0 a	LiTu, AcRu, AiAl
Toe	4	24.6 b	600 ab	5.5 a	LiTu, AcRu, OxAr
Side	5	22.0 bc	725 a	6.4 a	LiTu, AcRu, OxAr
Shoulder	5	20.0 c	670 ab	5.4 a	QuPr, OxAr, PiSt
Ridge	3	20.0 c	800 a	5.7 a	PiSt, OxAr, QuCo

TABLE 2. Number of plots (N), average diameter at breast height (DBH), tree density, species richness, and top three most abundant species by aspect in forested plots on the property of Ferrum College, Franklin County, VA. Means with the same letter are not significantly different at $p \leq 0.05$. LiTu = *Liriodendron tulipifera*, OxAr = *Oxydendrum arboreum*, AcRu = *Acer rubrum*, PiSt = *Pinus strobus*, QuPr = *Quercus prinus*, AiAl = *Ailanthus altissima*, QuAl = *Quercus alba*.

Aspect	N	DBH (cm)	Density (# / ha)	Species Richness	Most abundant species
NE	7	21.6 a	685 a	6.3 a	LiTu, OxAr, AcRu
NW	1	22.4 a	650 a	4.0 a	OxAr, PiSt, AcRu
SE	3	23.4 a	633 a	6.0 a	AcRu, LiTu, QuAl
SW	3	21.6 a	675 a	5.0 a	PiSt, QuPr, OxAr

(*Acer rubrum*). Red maple was found in every plot and sourwood appeared in all but three of the plots. Tulip tree was found in slightly over half of the plots, but it was abundant in the plots in which it was located. White pine (*Pinus strobus*), and chestnut oak (*Quercus prinus*) were also common in plots of this study.

Some trends were observed with respect to tree density and DBH by the topographic slope classification. In general, tree density increased with ascending topographic position while DBH decreased. Valley plots had a larger mean tree DBH than all other positions (Table 1) and toe slope positions had a significantly higher mean tree DBH than shoulder or ridge top topographic positions. Tree density tended to increase with topographic position (Table 1). Species richness did not differ significantly by topographic position (Table 1). No significant differences were observed for aspect in mean tree diameter, species richness, or tree density (Table 2).

Cluster analysis (Figure 1), revealed three main types of forest tree communities. The attributes of these groups with respect to DBH, tree density, species richness, and

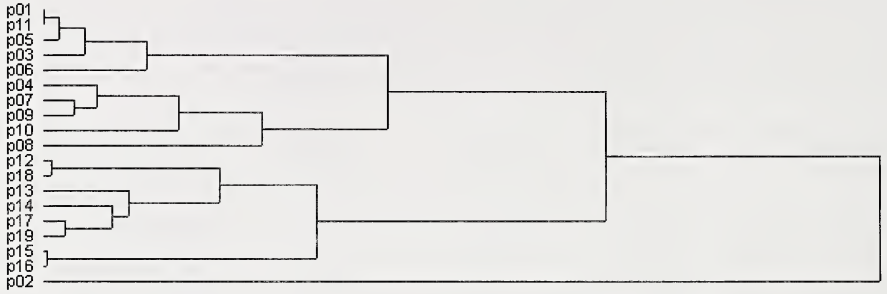

FIGURE 1. Cluster analysis of the plots within forests on the property of Ferrum College, Franklin County, Virginia. The first cluster of plots 1, 11, 5, 3 and 6 were plots with a modal tendency for toeslope positions and northeastern aspects. Cluster two of plots 4, 7, 8, 9 and 10 represented mostly shoulder and sideslope plots. Plots 12-19 made up the third cluster occurring most often on southwestern aspects and ridgetop or shoulder. The main outlier plot identified from the cluster analysis was plot 2, a plot with a very high density (80%) of tuliptree.

TABLE 3. Number of plots (N), average diameter at breast height (DBH), tree density, species richness, highest mode(s) for topographic position (Mode TP), and aspect (Mode aspect), and top three most abundant species by major species groups identified in cluster analysis of forested plots on the property of Ferrum College, Franklin County, VA. Means with the same letter are not significantly different at $p \leq 0.05$. LiTu = *Liriodendron tulipifera*, OxAr = *Oxydendrum arboreum*, AcRu = *Acer rubrum*, PiSt = *Pinus strobus*, QuPr = *Quercus prinus*, AiAl = *Ailanthus altissima*, QuCu = *Quercus coccinea*.

Species Group	N	DBH (cm)	Density (# / ha)	Species Richness	Mode TP	Mode Aspect	Most abundant species
1	5	26.2 a	540 a	5.4 a	Toeslope	NE	LiTu, AcRu, OxAr
2	5	24.4 ab	495 a	6.0 a	Sideslope Shoulder	NE SE	OxAr, AcRu, QuPr
3	8	20.2 b	756 b	5.1 a	Ridgetop Shoulder	SW	PiSt, QuCo, QuPr

most abundant species is summarized in Table 3. According to cluster analysis (Figure 1), the first cluster of plots 1, 11, 5, 3 and 6 were plots with a modal tendency for toe slope positions and northeastern aspects (Table 3). All but one of the plots contained in this cluster had an easterly aspect and the plots in this cluster were dominated by tulip tree and red maple. Cluster two of plots 4, 7, 8, 9 and 10 represented mostly shoulder and side slope plots. These plots were characterized by eastern aspects and relatively high densities of sourwood, red maple, and chestnut oak. Plots 12-19 made up the third cluster. Cluster three occurred most often on southwestern aspects and ridgetop or shoulder positions. Plots in cluster three contained relatively high densities

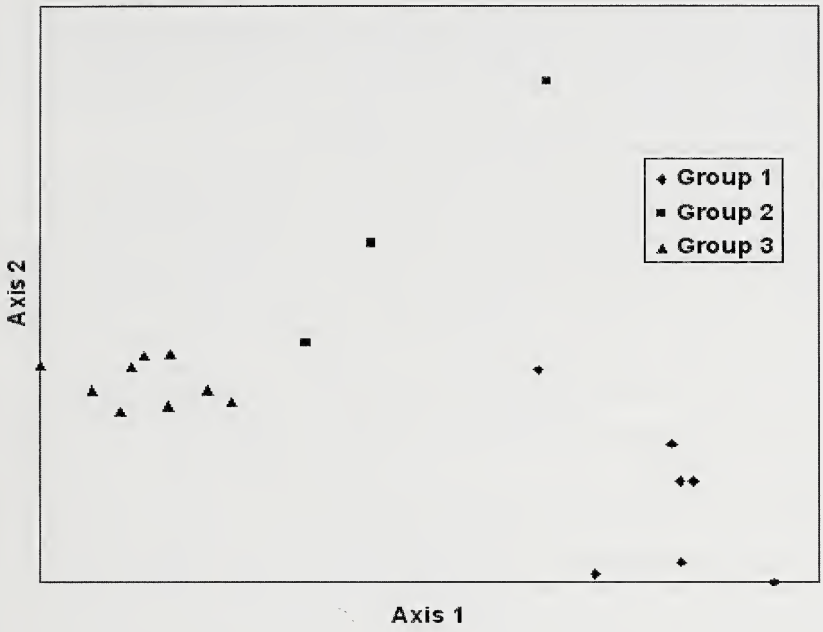

FIGURE 2. Plot of the first two axes of a detrended correspondence analysis (DCA) showing stand scores on plots within forests on the property of Ferrum College, Franklin County, Virginia. DCA results are similar to those of cluster analysis, except that more stands in the intermediate group 2 were placed in the ordination with mesic stands (group 1) and more xeric stands (group 3). The first group included plots 1-6, and 11. The second group included plots 7-9. The third group included plots 10 and 12-19.

of white pine, scarlet oak, and chestnut oak. The main outlier plot identified from the cluster analysis was plot 2, a plot with an 80% relative density of tulip tree.

Detrended correspondence analysis (Figure 2) ordered stands along the principal axis (eigenvalue = 0.70) from moist (lower slope positions and northern and eastern aspects) to drier sites (upper slope positions and southern and western aspects). The second axis had an eigenvalue of 0.20 and, despite down-weighting of rare species, appeared to be driven by appearances of relatively rare species in certain plots. DCA groups stands somewhat similarly to the cluster analysis except that it grouped plots 2, 4, 6, and 11 with the stands in cluster group 1 and included plot 10 with cluster group 3.

DISCUSSION

Topographic factors did not have a definitive influence on species composition in this study, although it was possible to differentiate three different species groupings that appeared to be influenced by topographic position and, to a lesser extent, by aspect. The lack of strong relationships between topographical variables and species composition is possibly attributable to a range of factors including a relatively large

number of common species in this study considered to be generalists with respect to environmental variation (e.g., red maple, white oak, sourwood, white pine), a lack of extremes in topographic variation (low variation in altitude and slope percentage), and offsetting effects of topographic variables with respect to moisture and soil fertility (e.g., plots on southwestern slopes on lower slope positions).

DCA and cluster analysis isolated species more common on mesic, toe slope positions, such as tulip tree, red maple, and ailanthus. Tulip tree is one of the most common forest tree species on mesic locations in Franklin County (Carter and Fredericksen 2007), often forming almost pure stands on lower slopes with north and east aspects. Many of these trees probably became established following logging operations early in the 20th century. Ware (1998) did not find an abundance of tuliptree in a study of Blue Ridge forests, but these were probably avoided because that study avoided post-cultivation stands and therefore may have been under represented. Red maple was an abundant canopy and understory species in a study of Blue Ridge Forests by Farrell and Ware (1988). Braun (1950) described red maple as a species with wide ecological amplitude being present on all but the most mesic cove forests and dry ridges. White pine occurred on many plots in this study, but tended to reach its highest abundance on upper slopes, where it often shared dominance with oak species. Scarlet oak was also common in these same stands. White pine and scarlet oak were not common in the studies by Ware (1998) or Farrell and Ware (1988). Chestnut oak was observed mostly on stands on shoulder and ridge top positions in this study.

Aspect did not exert a strong influence in this study, perhaps because of its interaction with topographic position and percent slope. Stephenson (1982) studied exposure-induced differences of north- and south-facing slopes in southwestern Virginia and found that while some species were found on both aspects, most species were more specific to one exposure than the other (Stephenson 1982). In our study plots, red maple and sourwood were often found in plots of both east- and west-facing aspects. Most other trees, however, were found primarily in plots with an eastern or western aspect. Tulip tree and other mesophytic tree species were found primarily in plots with an eastern aspect, while plots with a western aspect had more oak and pine.

Forest composition in this study was invariably affected by light selective logging that took place approximately 30 years ago. Three of the main beneficiaries of this logging included red maple, sourwood, and ailanthus. Red maple is increasing in abundance in eastern forests for a number of reasons including its wide ecological amplitude and the reduced influence of fire (Abrams 1998). Sourwood is a species that normally occupies intermediate positions in the canopy and was not subjected to logging. Ailanthus probably invaded stands after logging, becoming established in gaps where logging equipment exposed mineral soil (Carter and Fredericksen 2007). Finally, the influence of topographical features on species composition may be confounded with historical patterns of forest clearing and farmland abandonment. With their higher soil fertility, valley and toe slope positions were probably cleared earlier and abandoned later than ridge top and shoulder positions. Steeper slopes were probably also abandoned earlier than more moderate slopes.

Although the effects of topographic position were not pronounced in this study, we were able to detect some associations of species groupings with topographic position and aspect in the stands studied in the upper Piedmont. A relationship was also

observed for a general increase in tree density with ascending slope position while mean tree DBH decreased. Species richness did not differ significantly by topographic position or aspect.

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New Records, Biogeography, and Habitat Protection Needs of Four Species of *Potamon* (Decapoda: Brachyura) in Greece

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ABSTRACT

Objectives are to determine the occurrence of species of *Potamon* in eastern Crete and the Aegean Islands (Chios, Naxos, Paros, Mykonos, Tinos and Andros); generate phylogenetic relationships among species to propose a biogeographic hypothesis relative to current distributions of the four species of the freshwater crab genus, *Potamon*, in Greece; and comment on the need to protect habitat suitable for the survival of species of *Potamon* in the country. Our collections, made in areas not previously sampled by researchers, indicate the presence of *Potamon fluviatile* on Tinos, Naxos, and Andros, and *Potamon potamios* from central to eastern Crete; and verified the presence of *Potamon ibericum* on Chios. Cladistic analyses resulted in a single parsimonious tree (CI=85, RI=75). *Potamon* in the Balkan peninsula and islands in the Mediterranean region is a monophyletic group composed of two main clades: Clade 1 (*P. fluviatile* and *Potamon algeriense*) and Clade 2 (*P. ibericum* and its sister group composed of *Potamon rhodium* and *Potamon potamios*). Vicariant events (e.g. marine transgression and regression, orogeny, volcanism) are hypothesized as major factors that have shaped current distributions of species of *Potamon* in the Balkan Peninsula, Asia Minor, and the islands of the North Aegean Sea, Eastern Sporades, the Cyclades, and Crete. We recommend an increase in environmental education and communication among older and younger generations, agriculturalists, politicians, policy writers, land developers and economists to create an understanding for the need to protect land and aquatic environments that harbor unique species and the potential benefits for economic activities such as ecotourism. We also recommend the creation of an action plan to develop ecotourism around conservation areas (e.g. from the source of existing springs downstream for about 200 m before the installation of water withdrawal equipment for irrigation and potable supplies) to generate revenue for funding protection initiatives and to promote green economic development that is ecologically and socio-culturally sustainable.

Keywords: *Potamon*, biogeography, habitat protection

INTRODUCTION

In response to the European Environmental Agency's (EEA) biodiversity initiative to inventory, identify, and describe aquatic and terrestrial species in European Union (EU) countries, Maurakis et al. (2004) provided an update to the distributions of freshwater crab species of *Potamon* (Decapoda: Brachyura) relative to lotic stream factors in Greece. Significant gaps in distributional records of both freshwater crabs and fishes and the absence of sampling in some areas (e.g. Aegean Islands and eastern Crete), however, have hampered the creation of the biodiversity inventories needed for determining candidate protection areas, conducting environmental impact studies, and understanding biogeographic mechanisms (Bobori et al., 2001; Maurakis et al., 2004; 2003). Additionally, climate change (hotter and drier conditions) and increased anthropogenic influences (i.e., surface water withdrawal and high rates of ground water pumping) over the past 40 years have decimated water resources and degraded remaining aquatic habitats in significant portions of Greece (Bobori et al., 2001). Water extraction has resulted in fragmented, polluted, and xeric aquatic habitats that have led to the extirpation of native fish and crab species in this Mediterranean country on the European fringe. Without a national action plan to monitor and manage aquatic resources (Economou et al., 2000; OECD, 2000), desertification, which already is increasing (Yassoglou and Kosmas, 2000), will accelerate and permanently alter the land towards a Middle Eastern environment.

Objectives of the study are to determine the occurrence of species of *Potamon* in eastern Crete and the Aegean Islands (Chios, Naxos, Paros, Mykonos, Tinos and Andros); generate phylogenetic relationships among species to propose a biogeographic hypothesis relative to current distributions of the four species of the freshwater crab genus, *Potamon*, in Greece; and comment on the need to protect habitat suitable for the survival of species of *Potamon* in the country.

Geologic, Tectonic, and Eustatic Descriptions of Study Area

In a relatively short amount of geologic time (58 my), a variety of events have taken place in the Balkan Peninsula and surrounding areas which make this area both fascinating and challenging for the study of the relationships among groups of organisms (Maurakis and Economidis, 2001; Maurakis et al., 2001). The following is a summation of the events, which have played an important role in shaping the study area as it occurs today, and the distributions of species of *Potamon* in the region.

During the Eocene and Oligocene (58-22 mya), the Afro-Arabian continent moved towards and collided with the Eurasian continent (=Alpine collision). During this collision, the Pindus thrust was initiated and led to the creation of the Pindus Mountain range in western Greece (Clews, 1989). Compressional forces were strong, and by the Miocene (22-5 mya) oceanic crust began to sink northward below the Aegean in a newly formed subduction zone, the Hellenic Trench. Many events precipitated in response to the opening of this subduction zone. Just north of the Hellenic Trench, formation of the non-volcanic Hellenic arc emerged due to the crust above the subduction zone arching upwards. Islands of Crete, Karpathos and Rhodes, the western edge of Peloponnesos, and southeastern Turkey form this Hellenic arc (Angelier, 1982). As the subducting ocean slab began to melt, the South Aegean volcanic arc, which spans from Corinth to the Dodecanese, formed and grew further north of the Hellenic arc (Higgins and Higgins, 1996). This volcanism, beginning about 5 mya, continues today in the Cyclades Islands of Milos and Thera (Higgins and Higgins, 1996). In

response to subduction and volcanism, extensional forces developed and created a back-arc basin in the Aegean region. A series of horsts and graben structures, many with roughly NW/SE orientation, resulted from this Neogene extension. Several of the rivers (e.g. Nestos, Strymon, Axios, Loudias, and Aliakmon) in our study area presently flow down valleys formed by these grabens.

The North Aegean Trough, associated with the North Anatolian Fault Zone (FZ), is an important feature that developed during the Neogene extension. The North Aegean Trough is 1000-1500 m deep where surrounding basins (e.g. Thrace Basin, Strymon Basin) constitute the southern margin of the European plate (LePichon and Angelier, 1979). The North Aegean Trough runs in a NNW/SSE orientation from the Saros Trough in the east to Magnesia on mainland Greece in the West (Lyberis, 1996). The North Anatolian FZ, a prominent right lateral strike-slip fault, runs horizontally beneath the Sea of Marmara, the Gallipolis Peninsula north of the Dardanelles, and along the North Aegean Trough where it terminates near Skiathos near the Pelion Peninsula (Higgins and Higgins, 1996).

Along with these tectonic events, the Aegean region has experienced a handful of eustatic changes in sea level, which have set the stage for joining and severing ancient river drainage systems, and islands in the Aegean. Rising and lowering sea levels have been triggered by tectonic and climatic events (Rogel and Steininger, 1983). For example, the Alpine collision triggered a widespread regression 20 mya (Rogel and Steininger, 1983). During the Tortonian (10 mya), a major transgression followed by regression occurred. During the Messinian (5.1 mya), glaciation of the West Antarctic ice sheet increased, which led to worldwide regression (Bianco, 1990). Coupled with this lowering of sea level, Hsu (1983) believes the Mediterranean dried into a desert, "Messinian Salinity Crisis," leaving only a few isolated freshwater lakes in the region. Soon, the Atlantic Ocean broke through the Straits of Gibraltar and flooded the Mediterranean region with salt water (Hsu, 1983), a significant barrier to freshwater faunas. Since then glacial and interglacial periods have been the primary factor controlling regressions and transgressions of the region. At the peak of the last glaciations (20,000ya), sea level was about 120 m below present levels (Higgins and Higgins, 1996). During this time, the Black Sea and Sea of Marmara were freshwater lakes, which drained into the Dardanelle's valley. By 8000 BCE, sea level of the Mediterranean Sea began to rise rapidly to its present level, encroaching on the Dardanelles, Sea of Marmara, Black Sea and ancient river drainage systems. With sea levels and climatic conditions remaining relatively constant for the last 8000 years, the study area has endured much weathering and erosion. Coupled with this, movement along fault lines within both compressional and extensional regions and subsidence of basins have played roles in shaping and molding the landscape of the region.

MATERIALS AND METHODS

Specimens of *Potamon* collected by hand, seines and dip nets from sampling sites in stream and riparian habitats, were preserved in 95% ethanol and transported to the laboratory for identification (Appendix 1).

Two characters, terminal and subterminal segments of 1st pleopod in males presented in Brandis et al. (2000) and Pretzmann (1983, 1962) were used to identify male *Potamon* spp.:

P. fluviatile: flexible zone of male gonopod V-shaped, and subterminal segment of Pl.I S-shaped with inner lobe of terminal segment buldging strongly in a regular curve from base to just before tip;

P. ibericum: flexible zone of male gonopod broadened in its mesial part, and subterminal segment of Pl.I extended straight, length of terminal segment of Pl.I at most 0.4 x length of subterminal segment, greatest width at base, approximately spherical;

P. potamios: flexible zone of male gonopod symmetrically bilobed; subterminal segment of Pl.I extended straight, length of terminal segment of Pl.I rather less than 0.33 of length of subterminal segment, segment very seldom somewhat greater than 0.33, greatest width about middle, or distal to middle; and,

P. rhodium: flexible zone of male gonopod distinctly V-shaped where top of "V" is situated directly on the subterminal median bulge.

Ten morphological characters in Brandis et al. (2000) and Pretzmann (1983, 1962) for *P. fluviatile, P. ibericum, P. potamios*, and *P. rhodium* were identified and determined as primitive or derived by out-group comparison (Table 1). *Potamon* (*Orientopotamon*) *gedrosianum* distributed in Afghanistan and Pakistan was used as the out-group. The computer program *hennig86* (Farris, 1988; Lipscomb, 1994) was used to construct cladograms of species using the options *ie** which generates cladograms by an implicit enumeration algorithm and retains all parsimonious cladograms. The relative quality of results was judged using the consistency index (CI), a measure of the degree to which characters changes on the cladogram are minimal (see Kluge and Farris, 1969), and the retention index (RI), a measure of the amount of relatedness hypothesized by the presence of characters that is not in conflict with the final cladogram (Farris, 1989). Multiple equally fit hypotheses of relationships of the species were re-evaluated using successive weighting (command *xs w* in *hennig86*), a procedure that reanalyzes after down-weighting data that are in conflict with initial results (Farris, 1969; Carpenter, 1988). *Winclada* (Nixon, 1999) was used to plot characters and character states per node.

RESULTS AND DISCUSSION

With the exception of Paros, *P. fluviatile* was found on all Aegean islands sampled (Naxos, Tinos, and Andros)(Fig. 1). Our collections are new distribution records that extend the range of *P. fluviatile* to Tinos and Naxos, and confirm the continued presence of the species on Andros, where the species was last reported extant by Pretzmann in 1980. Our records of *P. potamios* in eastern Crete extend the range of the species from central Crete to the eastern and southeastern portion of the island, where freshwater habitats are scarce (Fig. 1). Previously, the easternmost record of *P. potamios* was in the Lasithi Plateau (Brandis et al., 2000). Our collections of adult male *P. ibericum* on Chios confirms the presence of the species on the island

TABLE 1. Characters and character states of *Potamon gedrosianum* (out-group) from Afganistan, in-group (*Potamon ibericum*, *Potamon fluviatile*, *Potamon rhodium*, and *Potamon potamios* from Greece, and *Potamon algeriense* from northern Africa).

	Character								
Species	1	2	3	4	5	6	7	8	9
P. gedrosianum	0	0	0	0	0	0	0	0	0
P. ibericum	1	1	0	1	1	0	1	2	2
P. fluviatile	0	0	1	1	1	0	0	1	1
P. rhodium	0	0	0	1	1	0	1	3	1
P. potamios	0	0	0	1	2	1	1	3	0
P. algeriense	0	0	1	1	1	0	0	1	2

Character 1. Carapace: 0=smooth and concave; 1=smooth and flat.
Character 2. Anteriorlateral carapace margin: 0=well developed; 1=Not well developed, small.
Character 3. 1st gonopod: 0=conical or slender, without swollen mesial part; 1=broad, oval-shaped with swollen mesial part.
Character 4. Serrations on anterior lateral carapace margin: 0=long teeth; 1=short teeth.
Character 5. Teeth on anterior lateral carapace margin: 0=pointed, unequal in length; 1=pointed, equal in length; 2=rounded, unequal in length.
Character 6. Chelipeds: 0=equal in length; 1=unequal in length.
Character 7. Shape and margin of male abdomen: 0=triangular with straight margin; 1=triangular with convex margin.
Character 8. Terminal joint of 1st gonopod:0=shortly triangular, with variable projecting medial edge; 1=large bulge with lateral margin strongly rounded; 2=spindle shaped; 3=elongatedly conical, mesial part not curved outwards.
Character 9. Flexible zone: 0=slightly bilobed; 1=V-shaped; 2=lobed.

previously based on two juvenile males and one leg reported by Brandis et al. (2000) and Pretzmann (1986), respectively (Fig. 1).

Cladistic analyses resulted in a single parsimonious tree (CI=85, RI=75; Fig. 2). Clade A is a monophyletic group (synapomorphic characters 4, state 1; and 5, state 2) composed of Clade B (*P. fluviatile* and *P. algeriense*) defined by one synapomorphy

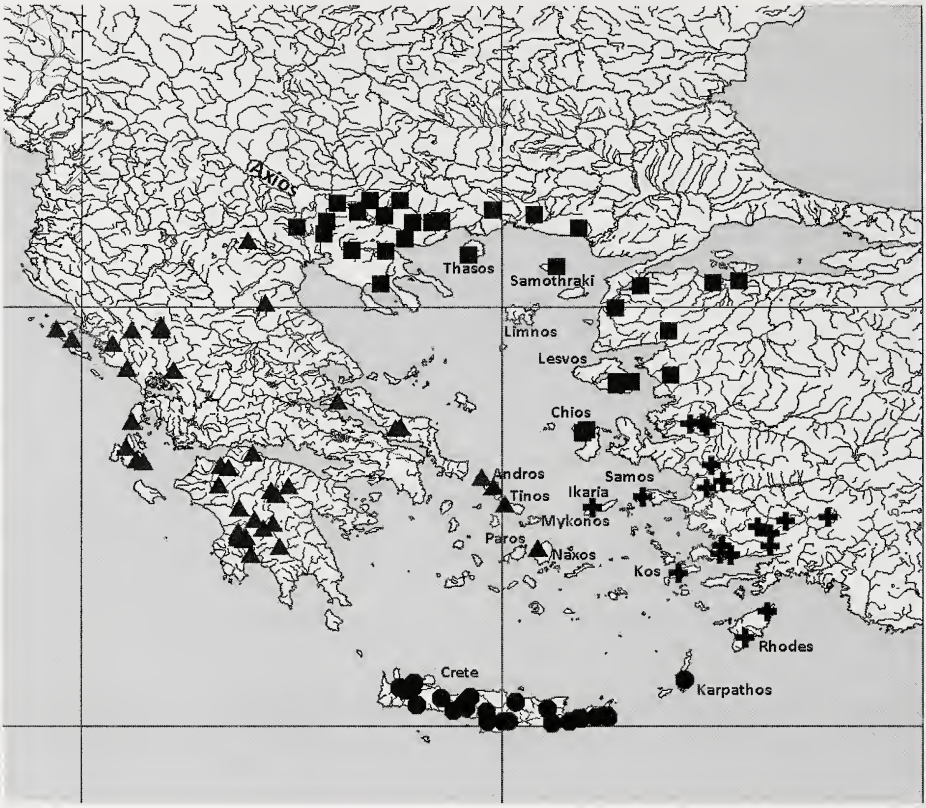

FIGURE 1. Collections sites of collections of *Potamon fluviatile* (▲), *Potamon ibericum* (■), *Potamon potamios* (●) and *Potamon rhodium* (✚).

(character 3, state 1) and Clade C. Clade C, defined by two synapomorphies (character 7, state 1; and character 8, state 2), is a monophyletic group composed of *P. ibericum* and its sister group, Clade D. Clade D, defined by one synapomorphy (character 8, state 3), is a monophyletic group composed of *P. rhodium* and *P. potamios* (Fig. 2).

Vicariant events (e.g. marine transgression and regression and orogeny) are hypothesized as major factors that have shaped relationships among river drainages and islands and current distributions of species of *Potamon* in mainland Greece on the Balkan Peninsula, and on the islands of the North Aegean Sea (e.g. Samothraki, Thassos, Limnos), Eastern Sporades (e.g. Lesbos, Chios, Ikaria, Samos, Rhodes, Kos), the Cyclades (e.g. Andros, Tinos, Naxos, and Paros), and Crete (Figs. 1 and 2). Dispersal of *P. fluviatilis* extended westward from ancestral populations in Anatoli and colonized mainland Greece and its geologically related Cycladic islands (e.g. Andros, Tinos, Naxos, and Paros), and then west to the Italian Peninsula. This is consistent with the geological evolution of the area, where the Cycladic islands are part of the Attica-Cycladic metamorphic belt, which continues north to Attica and southern

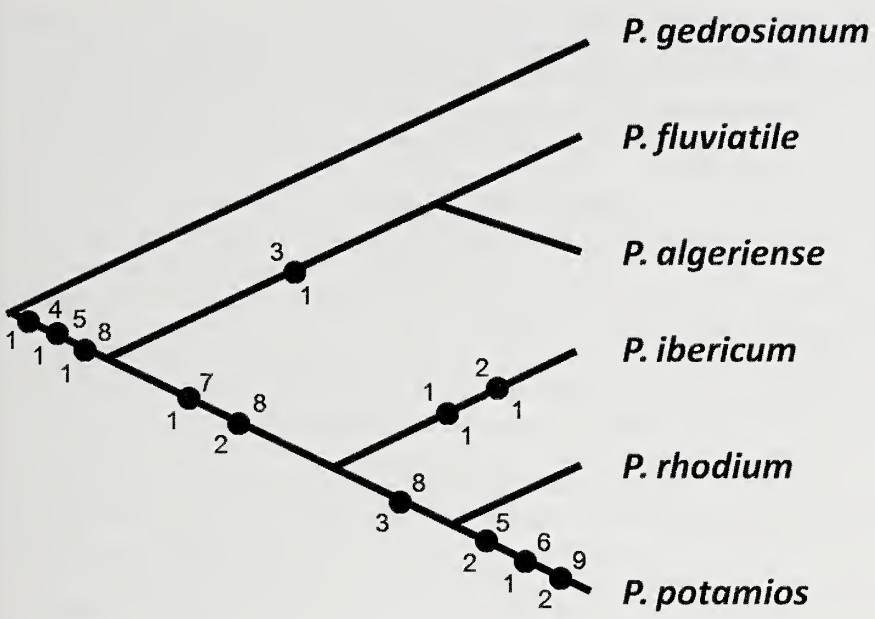

FIGURE 2. Phylogenetic relationships of in-group taxa (*Potamon fluviatile*, *Potamon ibericum*, *Potamon potamios*, and *Potamon rhodium* in Greece, and *Potamon algeriense* from Africa (out-group= *Potamon* (*Orientopotamon*) *gedrosianum*). Numbers over black dots (=synapomorphies) are characters; those below are character states.

Euboea (Higgins and Higgins, 1996). Populations of *P. fluviatilis* probably extended to North Africa prior to the Messinian Salinity Crisis (5.1 mya) during which time (~0.5 my) the region was a steppe landscape which could have supported crab populations in lakes between Sicily and Northern Africa (Stanley and Wenzel, 1985). After the Atlantic Ocean broke through the Straits of Gibraltar, populations in Northern Africa, now recognized as *P. algeriense*, became isolated from those of *P. fluviatilis* in Italy. Our cladistic analysis corroborates the statements of Brandis et al. (2000) who used traditional evolutionary taxonomic methods to hypothesize the relationship between *P. fluviatilis* and *P. algeriense*.

We hypothesize that *P. ibericum* dispersed from Turkey westward to Greece prior to the Mediterranean transgression of the Sea of Marmara and Black Sea, and competitively replaced populations of *P. fluviatilis* east of the Serbo-Macedonian massif, just east of the Axios River (Figs. 1 and 2). Populations of *P. ibericum* on the islands of Thassos, Samothraki, Limnos, Lesvos and Chios are a result of their proximate connections to the mainland prior to marine transgression. Current water depths between all of these islands and their respective mainland areas are 100 m, less than that of the marine transgression of 120 m when the Atlantic Ocean flooded the Mediterranean area after the Messinian Salinity Crisis (Higgins and Higgins, 1996).

The Menderes River and a 1000 m trough in the eastern Aegean Sea south of Chios separate southern populations of *P. ibericum* on Chios and central Anatoli from Clade

D (*P. rhodium* and *P. potamios*), derived from an ancestral population in southern Anatoli (Figs. 1 and 2). Distribution of *P. rhodium* is limited to a small area of southern Anatoli and the islands of Samos, Ikaria, Kos and Rhodes. Water depth between these islands and the mainland vary between 100-400 m, and suggest that *P. rhodium* was probably present on these islands prior to the Messinian Salinity Crisis. Rhodes is separated from Anatoli by a channel 400 m deep, and to the south of the island, the sea-floor drops off rapidly to a depth of over 3000 m in the Rhodes basin (Higgins and Higgins, 1996). We hypothesize the 3000 m deep trench served as a barrier separating populations of *P. rhodium* from the more southern populations of its sister species, *P. potamios*, which occurs on the islands of Crete, Karpathos, and Cyprus, and in the Jordan River system.

A significant number of perennial streams that existed 20 or more years ago in the eastern portion of Crete, and those on islands (e.g. Chios, Mykonos, Naxos, Paros, Tinos) have become completely dry (pers. obs). The desiccation of streams has been directly related to climate change (i.e., reduced precipitation frequency and amount) and increased water withdrawal from springs, streams, and subterranean aquifers for crop irrigation and potable water supplies for an increasing population (particularly in the tourist industry). Unsustainable agricultural policies and common agricultural practices (CAP), and water and soil resource schemes have resulted in loss of 75 % of wetlands in Greece since 1900 (OECD, 2000). As a result, flourishing populations of *Potamon* do not exist in most areas (e.g. central and eastern Crete) that once harbored crabs as large as 18.5 cm in carapace width (Manos Sambobalakis, Ierapetra Taverna, pers. comm., 2007). In interviews of 14 local inhabitants from Kato Zakros on the east coast of Crete west to Archanes in the middle of the island, we determined that *Potamon* crabs had been a significant part of Cretan culture. The freshwater crab was part of the diet of locals and Greeks after 1200 BCE (Joseph Shaw, University of Toronto, pers. comm., 2007), a source of play for children (Stella Ailamaki, Stella Apartments Villa, pers. comm., 2007), in archaeological remains and artwork of Minoans at Kommos and Knossos around 1600 BCE (Evans, 1928; Shaw and Shaw, 2000), and as the basis of at least one song (pers. obs.). As *Potamon* populations are interwoven into the cultural fabric of local Cretan communities, and are one of the largest freshwater macrobenthic organisms whose ecological position is not well understood, we recommend the following: (1) increase environmental education and communication among older and younger generations, agriculturalists, politicians, policy writers, land developers and economists to create an understanding of the need to protect the land and aquatic environments that harbor unique species and the potential benefits for economic activities such as ecotourism; and (2) create an action plan to develop ecotourism around conservation areas (e.g. from the source of existing springs downstream for about 200 m before the installation of water withdrawal equipment for irrigation and potable supplies) to generate revenues for funding protection initiatives and to promote green economic development that is ecologically and socio-culturally sustainable as discussed in Lekakis (1998). The alternative development and biodiversity conservation projects in the Prespa lake system in northwestern Greece and the Dadia-Lefkimi-Soufli forest reserve in northeaster Greece discussed by Valaoras (1998) could serve as models for such a plan.

ACKNOWLEDGMENTS

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APPENDIX I

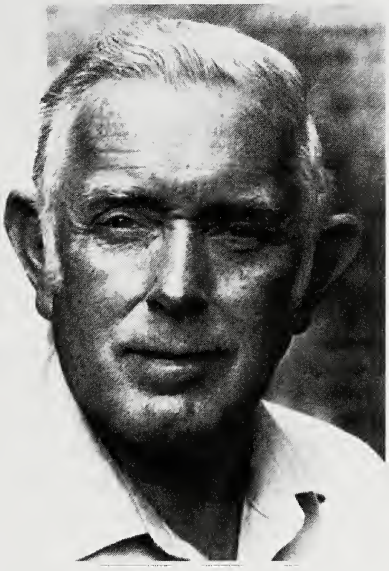
Locality data (island, prefecture, collection number, locality, data and number of crabs collected or no water in parentheses for species of *Potamon* collected from Greek islands in 2004, 2006, and 2007.

Potamon fluviatile: Mykonos Island, EGM-Mykonos-604, marsh pond at Panomas Beach, 17 July 2006 (0); EGM-Mykonos-605, Lake Maou in NE Mykonos near Fokos Beach, 17 July 2006 (0). Paros Island, EGM-Paros-606, stream in Valley of Butterflies at Biotpoe Petaloudes, about 8 km S of Parikia-Paros, 18 July 2006 (0). Naxos Island, EGM-Naxos-607, unnamed stream discharging into Amiti Bay, 0.4 km NE of Egares, about 7.5 km NE of Naxos Hora, 18 July 2006 (3). Tinos Island, EGM-Tinos-608, Rematia Venia in town of Pyrgos, 20 July 2006 (2); Andros Island, EGM-GR-609, Dionysos Spring at Patouria, about 6 km NW of Andros Hora, 22 July 2006 (1).

Potamon ibericum: Chios Island, EGM-GR-602, Panagia stream (Potamos Velesou), 3.5 km ENE of Volissos, 16 July 2006 (5); EGM-GR-603, Springs of Potamos Velesou, 1.2 km NE of Fyta, about 9 km NE of Volissos, 16 July 2006 (2).

Potamon potamios: Crete, Xania Prefecture: EGM-R-584, Keritas River, 0.5 km E of Alikianos, 10 km SW of Xania, 19 June 2004 (0); EGM-GR-585, SE branch of Keritas River, 1 km E of Forne, 12 km SW of Xania, 19 June 2004 (2); EGM-GR-586, E branch of Tavronidis River at Pappadiana, 4.5 km N of Nea Roumato, 20 km SW of Xania, 19 June 2004 (5); EGM-GR-587, East branch of Tavronidis River at Limni, 20 km SW of Xania, 19 June 2004 (No water); EGM-GR-588, East branch of Tavronidis River at Zounaki, 18 km SW of Xania, 19 June 2004 (No water); EGM-GR-589, Tavronidis River under new main road between Skoutelonas and Vamvakopoulo, 11 km SW of Xania, 20 June 2004 (0); EGM-GR-590, Keritas River, about 14 km SW of Xania, 20 June 2004 (0); EGM-GR-591, unnamed tributary flowing into Stylia, 15 km W of Xania, 20 June 2004 (1); EGM-GR-592, Lake Kourna, about 16 km WSW of Rethymnon, 21 June 2004 (1); Rethymnon Prefecture: EGM-GR-593, unnamed stream in Fangarri Gorge, upstream of Amari Dam being constructed, about 15 km SE of Rethymnon, 21 June 2004 (3); Iraklion Prefecture: EGM-GR-578 and EGM-GR-596, unnamed creek in Kateros Gorge at Agia Irini, about 0.5 km S of Spilia, 10 km S of Iraklion, 15 and 22 June 2004 (2), respectively; EGM-GR-579, Anapodaharis River in Demati, 14 km E of Pirgos, 15 June 2004 (1); EGM-GR-580, Geropotamos River, 0.5 km N of Agia Triada, 5 km SE of Tymbaki and 7 km NE of Matala, 16 June 2004 (0); EGM-GR-581, Geropotamos River at bridge aside military base, 1.5 km SE of Tymbaki, 17 June 2004 (0); EGM-GR-583, unnamed tributary at Schinaria Beach, 1 km SE of Demoni, 18 June 2004 (4); Lasithi Prefecture: EGM-GR-20071, Xaxlakies Gorge, about 9 km E of Sitia, 18 June 2007 (No water); EGM-GR-20072, Springs of Ano Zakros, about 15 air km SE of Sitia, 19 June 2007 (6); EGM-GR-20073, on road between Ano Zakros and Azokeramos, photographed by Elias Ailamaki, 19 June 2007 (1); EGM-GR-20074, crab midden at base of N wall of room 14, Minoan Palace at Kato Zakros, 20 June 2007 (1); EGM-GR-20075, garden in Stavrochori, 18 km NE of Ierapetra, 2003 (1); EGM-GR-20076, sidewalk in Stavrochori, 18 km NE of Ierapetra, 2003 (1); EGM-GR-20077, unnamed spring fed tributary above Stavrochori, 18 km NE

of Ierapetra, 22 June 2007 (1); EGM-GR-20078, unnamed spring fed stream at Orino, 16 km NEW of Ierapetra, 22 June 2007 (1); EGM-GR-20079, spring between villages of Kato Chori and Pano Chori, about 5 km NE of Ierapetra (1); EGM-GR-200710, stream at Myrtos, 15 km W of Ierapetra (1); EGM-GR-200711, at spring on road to Thripti between Kato Chori and Pano Chori, 23 June 2007 (1).



Kenneth R. Lawless

Kenneth R. Lawless died Aug. 24, 2007. He served in the U.S. Army Air Forces attaining the rank of captain. He received a Fulbright Fellowship and spent a year conducting research at the Norwegian Institute of Technology in Trondheim. Mr. Lawless served as a research scientist and professor at U.Va. for more than 40 years, retiring in 1992 as a professor emeritus. Among his many contributions to the University, he was instrumental in creating the Department of Materials Science and Engineering and served as its chairman for 10 years. Mr. Lawless was an internationally recognized authority in the field of electron microscopy. He served as president of the Virginia Academy of Sciences and councilor, treasurer and member emeritus of the Microscopy Society of America. In 1989, Mr. Lawless was selected for membership in the Fellows of the Virginia Academy of Science. Among numerous awards and commendations, he received the J. Shelton Horsley Research Award, the highest honor bestowed by the Virginia Academy of Science for original research. He also received the Morton D. Maser Distinguished Service Award from the Microscopy Society of America. He was a member of Alpha Chi Sigma chemistry fraternity, Sigma Xi, Phi Beta Kappa and the Raven Society. At various times, Mr. Lawless served on the Fulbright Fellowship selection committee and the U.Va. Medical School admissions committee. He was also an ornithologist, field botanist and nature photographer. He was a longtime member of the Virginia Society of Ornithology and the Virginia Native Plant Society. A photographer of wildflowers, he conducted exhibits and lectures at the National Arboretum, the Nature Conservancy and elsewhere. Survivors include children **Kenneth W. Lawless** (Col.' 77) and **Lelia-Anne Lawless** (Col' 84, Educ' 92).

Virginia Academy of Science, Executive Committee Meeting
Saturday, March 29, 2008
Science Museum of Virginia
Presiding: Werner Wieland

1. **Call to Order:** The meeting was called to order at 9:30 am

2. **Approval of Minutes:** The minutes of November 18, 2007 Executive Committee recommended for approval with changes.

3. **Local Arrangements Committee:**

(i) Based on the conference site visit held on March 28, 2008 Dr. Whitney, chair of the local arrangements committee reported the

- The arrangements for meal and room assignments are finalized.
- Equipments is continue to be tracked down there does not seem to be any problem.
- Working on confirmation of availability of the tech support
- A separate telephone number will be available for the conference
- Dr. Harvey will deliver Jeffers Memorial Lecture on Tuesday night.
- Dr. Roger Crouch, astronaut from NASA will speak on Wednesday evening for VJAS at the Virginia Air and Space Center
- Sidney S. Negus Memorial Lecture will be delivered by Dr. Pat McCormick on Thursday
- Prof. Willis is working on the program book
- Final version of drafts of various forms, including electronic payment form is underway
- Few details are to be worked out about hotel accommodations

(xi) Jerry asked for the names of any guests who would make remarks during the meetings so that their names can be included in the program book, or a separate table can be reserved for them.

12. **Officers Report:**

President:

- Reiterated the items from the report by chair of the local arrangement committee about his conference site visit on March 28, 2008
- Issue of paper presentation by members/non-members under "statistics" category was discussed

President Elect:

- Working on missing information in the academy directory including dates
- Reported that NAAS has approved a resolution on State Science & Technology Policy February 18, 2008 (Appendix A)
- Several suggestions were made to generate interest for increasing the number of academy members including organizing a symposium in 2009

Vice President:

- Annual Meeting Program book is almost complete and will send to some members for review
- Needs clarification on few items from VJAS director Mrs. Booth and chair, local arrangement committee Dr. Whitney before finalizing the program book
- Sessions on Geography and Geology not needed and material science is in "Astronomy, Mathematics and Physics
- Because of low numbers multiple sessions on Medical Science is cropped of

Secretary: Minutes from last meeting was submitted for approval

Treasurer: No report

Executive Officer:

Reported that:

- the tax papers are ready to be filed
- the funds have been transferred to funds for the future
- the meeting with new director of Science Museum was cordial and we are well supported by the museum, a copy of history of the Academy was presented to the new director
- retreat reservation has been made for Sept 19, 2008 for 15-20 people. Reporting Friday evening and retreat finishes Saturday afternoon. Jim will have a tight agenda for retreat
- received one paper for Shelton Horsley Research Award which has been forwarded to the Chair, research committee Dr. Mohamed
- Under Graduate research symposium held in Fall has helped recruit students and faculty

Following hand-outs, including reports from Chair, Trust Committee Dr. Falls were distributed:

- Summary of Receipts, Disbursements and Year-end Balances for 2007
- Income/Expense Comparison by Category – 2006 (1-1-06 through 12-31-07)

- Historical account balance as of 12-31-2007 from American Funds
- Virginia Academy of Science Endowment Funds (12-31-07)
- Income/Expense Comparison by Category YTD-2 (1-1-2007 through 3-25-2008)
- VJAS Endowment – Accounting for Awards held in Endowment Mar 2008
- Senior Academy Awards and Funds March 2008

Better breakup for Trust category was requested

VJAS Director:

- Reported the numbers of papers received are less than previous year
- Few sections have to be merged
- Requested to encourage faculty to sign up for judges

Old Business:

Future Meetings sites:

- 2008 – Hampton University – site visit completed on March 28, 2008
- 2009 – VCU - Confirmed
- 2010 – JMU – No paper work is done yet; not to have meeting on memorial day weekend; during Wednesday – Friday
- 2011 – Radford University (Tentative)
- 2012 – Christopher Newport University (Tentative)
- Old Dominion University can be approached

New Business:

Following slate of nominations for offices is approved:

Jim Martin: President
Darcy Mays: President-Elect
Arun Verma: Vice-President
Michael Renfro: Secretary and
Rodney J. Dyer: Treasurer

Adjournment:

Meeting adjourned at 11:00 am

2008 COUNCIL MEETING
Saturday March 29, 2008
Science Museum of Virginia

1. **Call to Order:** The Academy Council Meeting called to order at 11:12 AM

2. **Approval of Minutes:** A draft of minutes of Council meeting held on November 18, 2007 was presented for approval. The minutes were approved with the following corrections:

   Under Reports –

   - Awards: "One nomination reported" should read as "One nomination for fellow has been received"

   - "Constitution & Bylaws – Gerry Taylor

     - Minor changes proposed (Appendix B – Constitution & Bylaws Committee Report to Council)*. It is to be done during Spring 2008 meeting". should read as

   "Constitution & By-laws – Jerry Taylor

     - Report submitted clarifying issues (Appendix B – Constitution & Bylaws Committee Report to Council)*"

   - Environment:

     - "Mary Washington University" should read as "University of Mary Washington."

   - Fellows: the only minute should read as

     - "Dr. Kenneth R. Lawless donated about 3000 pictures. Dr. Lawless, who was an academy fellow died in August 2007. He was 85."

   - Fund Raising: the minute should read as

     - "Requested advise from the Council for exploring a plan for fund-raising campaign with 90th anniversary celebration."

   - Under New Business: the third bullet should read as

     - "Names proposed for Research Committee – Joe D. Rudmin, Allison Baski, Lisa Alty, William Starnes"

7. **Financial Report:**

- Jerry presented the financial report and pointed out that the income from the annual meeting held at James Madison University was down for two reasons: Poor attendance and per person charge

- He indicated that to make the accounting simpler, trust description has been changed

- No significant change from previous year

11. **Annual Meeting update:**

- Dr. Harvey will deliver Jeffers Memorial Lecture on Tuesday night. Details to be sent to Jim O'Brian for newsletter.

13. **Reports:**

- Archives: Jeff Zadeh: Nothing to report

- Awards: Carolyn Conway

    - The committee consisting of Jim O'Brien, Victor Townsend and Andrew Dolby, nominated Dr. David G. Elmes of Washington and Lee University for the Academic Fellow.

- Constitution & By-laws: Jerry Taylor

    - Elsa Q. Falls, Chair Trust Committee serves as representative to Finance & Endowment committee

    - Arthur W. Burke, Jr. is chair of Finance & Endowment Committee

    - Two members are to be nominated for terms ending the following years

- Environment: Michael L. Bass

    - Reported that he has represented Academy at various conferences

- Fellows

    - Jim reported Rae could not be there and will not be there at the May's meeting either

- Finance & Endowment: Arthur W. Burke, Jr.

    - Expressed concern about reduced income

    - Reminded academy to stop spending from Trust funds

- Reduction of fees for Funds for the Future from 10% - to 5-7% was discussed as other institutions have around 4-5%
- Seek more outside funding
- Raising the meeting fees was discussed

- Flora of Virginia: Marion Lobstein
  - Updated on the *Flora of Virginia* Project
- Fund Raising: Jim O'Brien
  - Bruner Family
  - Approach Private Philanthropies using slides and material
  - TCC is not listed as a member institution
  - Various issues were presents at AAAS
  - Shared the NAAS recent resolution
- VJAS: Susan Booth
  - Reported the numbers of papers received are less than previous year
  - A few sections have to be merged
  - Requested to encourage faculty to sign up for judges
- Long Range Planning – Werner Wieland
  - Next annual meeting at VCU is on track
  - Chanco retreat September 19-20, 08
  - ODU contact person Paul Homsher
- Membership – Richard Groover
  - Report on Membership submitted in the last council meeting

- Nominations –
  - Slate of officers recommended by Executive Committee was presented and approved

- Darcy Mays is replacing Bob Willis for president-elect

- Publication – Jim Martin
  - The last issue of 2007 is two-weeks away from publication

- Research
  - received one paper for Shelton Horsley Research Award which has been forwarded to the Chair, research committee Dr. Mohamed
  - He is still willing to involve with academy work

- Science Advisory – Alan Griffith
  - No report

- Trust – Elsa Falls

  Following hand-outs, including reports from Chair, Trust Committee Ms. Falls were distributed:

  - Summary of Receipts, Disbursements and Year-end Balances for 2007
  - Income/Expense Comparison by Category – 2006 (1-1-06 through 12-31-07)
  - Historical account balance as of 12-31-2007 from American Funds
  - Virginia Academy of Science Endowment Funds (12-31-07)
  - Income/Expense Comparison by Category YTD-2 (1-1-2007 through 3-25-2008)
  - VJAS Endowment – Accounting for Awards held in Endowment Mar 2008
  - Senior Academy Awards and Funds March 2008

- VRSN – David Hagan
  - Report is attached

- Motion and approval of nomination of Dr. David Elm as academy fellow

32. Section Reports:

- Aeronautical & Aerospace Sciences - No Report
- Agricultural, Forestry, and Aquaculture - No Report
- Archeology - No Report
- Astronomy, Math, Physics, with Material Science - No Report
- Biology with Microbiology - No Report
- Biomedical & General Engineering - No Report
- Botany: Michael H. Renfroe
    - Has full schedule
- Chemistry: Tomas C. DeVore
    - Planning to open Dr. Urasa's symposium to all the attendees
- Environmental Science: Michael L. Bass
    - Among presentations received, most of them are posters and two are papers
- Molecular Biology: Now included in "Biology with Microbiology"
- Natural History & Biodiversity: Leeanna Pletcher
    - Werner reported a full program
- Psychology: Perry M. Duncan
    - Full morning session. Only one-third of what we had in past.
- Statistics - No Report

46. OLD BUSINESS

- No Old Business

48. NEW BUSINESS

- No new business

2. **Adjournment**: The council adjourned at 1:05 PM.

NOTES

VIRGINIA ACADEMY OF SCIENCE

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NOTES

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THE VIRGINIA JOURNAL OF SCIENCE

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VIRGINIA JOURNAL OF SCIENCE
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Vol. 59 No. 2 Summer 2008

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ABSTRACTS OF PAPERS, 86th Annual Meeting of the Virginia Academy of Science, May 20-23, 2008, Hampton University, Hampton VA

Aeronautical and Aerospace Sciences

A DESIGN CONCEPT FOR ALLEVIATING SOME SIZE CONSTRANTS FOR LARGE AIRCRAFT. M. Leroy Spearman, NASA-Langley Research Center, Hampton, VA 23681. The basic wing-body-tail arrangement of conventional transport aircraft generally consists of a central fuselage with forward-mounted wing panels attached to each side, and with aft-mounted tail surfaces. This arrangement has remained essentially unchanged over the years. and increased capacity has been achieved simply by increasing the overall size of the aircraft. However such an approach may be limited for aircraft beyond the size of the current jumbo jets such as the Boeing 747. For very large aircraft a serious problem may occur from the trailing vortex flow that would be generated at the wing tips under lifting conditions. The tip vortex presents a hazard to trailing aircraft that may be upset if they fly into the path of the vortex. Such a vortex would be much stronger than that for current transports because of the increased lift required for the larger aircraft. In an effort to alleviate such a problem some research has been conducted with an unconventional design for a large aircraft. The design consists of a large rectangular wing surface with large bodies attached to each wing tip. There are no outboard, wing panels such as those used on conventional aircraft designs. The use of two bodies of a conventional aircraft design results in doubling the capacity of the conventional aircraft. The large area of the rectangular wing provides adequate lift to sustain flight. The tip-mounted bodies act as end plates for the wing and the formation of a trailing vortex is precluded. Wind tunnel tests have been made of such a concept using two simulated Boeing-747 fuselages. Compared to a basic B-747, the resulting concept provides a payload capacity twice that of a B-747 with no increase in length, a decrease in span, and no trailing tip vortex.

SOME EVENTS FROM THE FIRST CENTURY OF FLIGHT. M. Leroy Spearman, NASA-Langley Research Center, Hampton, VA 23681 & Robert W. Heath , RRMC, Newport News, VA. Leonardo da Vinci envisioned man-flight in the 15th century and designed a practical airplane concept in 1490. Many other pioneers proposed various types of flying machines over the next 400 years but it was not until December 17, 1903 that the Wright Brothers, at Kitty Hawk, NC, were credited with achieving the first manned-powered flight. Over the next 100 years, several factors have influenced advances in aviation. The use of aircraft by European nations in World War I resulted in concern that the U.S. was lagging in aviation developments. This lead to an act of the U.S. Congress in 1915 that established the National Advisory Committee for Aeronautics (NACA) with the

charge to conduct aerodynamic research. The research began at Langley Field, VA in the early 1920's. Over the years this research has transformed low-speed, wood and fabric, propeller-driven airplanes into high speed, all-metal, jet-propelled airplanes. Jet and rocket propulsion enhanced the fields of supersonic and hypersonic aerodynamic flight and provided for access to space. In July 1955 the White House announced plans to launch an earth-orbiting satellite. Before this was done, however, the Soviet Union successfully launched Sputnik, the world's first artificial satellite in October 1957. This event caused concern that the U.S was lagging in the 'space race' and lead directly to the establishment of the National Aeronautics and Space Administration (NASA) in July 1958. The nucleus of the NASA was the existing NACA with the charge expanded to include space research. The skilled researchers at NASA-Langley have continued to provide improvements in aircraft developments and now contribute to the development of spacecraft as well.

Agriculture, Forestry and Aquaculture Science

THE EFFECT OF LARGEMOUTH BASS PREDATORS ON GROWTH AND FEEDING IN CHANNEL CATFISH. Michael L. Fine & Mark S. Mayo Dept. of Biol., VCU, Richmond, VA 23284-2012 and Edward N. Sismour & Scott H. Newton, VSU Agricultural Research Station, Petersburg, Virginia 23806. We examined the effects of largemouth bass predators on growth and feeding in channel catfish. Eight 75 gal tanks were divided in half with a plastic mesh, and 10 catfish were placed on the right side of each tank. The left sides were empty in four tanks (controls) or contained a largemouth bass predator (experimentals) in the other four. Bass were typically fed a channel catfish twice a week, and the experiment ran for 3 months. We measured catfish total length, weight and condition factor (W/L^3) to determine growth and recorded the number of pellets eaten, the time to eat 10 pellets, and catfish movement using a nonparametric scale from 0 to 3. Catfish grew significantly in both treatments, but weight and condition factor were higher in control fish than in experimentals. Control fish also ate twice as many pellets per minute and consumed more pellets than experimentals. Finally, control fish exhibited continuous movement, but experimentals typically remained stationary with low amplitude tail fluttering and opercular movements. When bass were fed a catfish, movement further decreased. Opercular movement stopped for about 15 sec after a latency of 24 sec, suggesting a chemical cue from catfish predation. Therefore, proximity of largemouth bass suppresses growth, feeding rate, amount of food consumed, and movement of channel catfish. Not only can bass predators affect survival of recently stocked catfish, they can retard the time it takes them to grow to a nonsusceptible size.

USING CYTOCHROME B TO DETERMINE SPECIES IN MIXED MEAT SAMPLES. Altamarie Woods & Brian L. Sayre, Dept. of Biology, Virginia State

University, Petersburg, VA 23806. Growth in world trade of animals, animal parts, food products for consumption and manufacturing intensifies the demand for product certification to warrant public and animal health safety standards. For example, ground meat labels that state the product is 100% of a species must be the only the species labeled. Current methods were unable to identify more than one species by using a single assay. The objective was to determine the feasibility of using microarray technology to identify species from mixed DNA samples. Mitochondrial DNA collected from samples of beef tips, chicken breast, and pork chops was amplified with primers for the cytochrome b gene (638 bp). This product was denatured, spotted onto nylon membranes, and cross-linked to the membrane. The target DNA was amplified in individual and mixed species samples with PCR using primers that produced a 95-bp product and was nested within the cytochrome b 638-bp product. The target DNA was hybridized for 3 hours to the microarray membrane. After hybridization the membrane was washed, developed, and imaged. The optimal hybridization temperature for the individual and mixed samples was 62° C and 60.5° C, respectively. The individual species samples were confirmed with hybridization of the target to a single probe on the array. Using the array, the identity of the species within the mixed species samples could be determined; however there were some false positives. This data indicated that the probes need further optimization to be conclusive. Based on the results of this project, one can conclude that microarray technology can be an effective tool for species identification, but will require more optimization.

THE RELATIONSHIP OF SWIMBLADDER STRUCTURE AND MATERIAL PROPERTIES TO ACOUSTIC FUNCTION IN SOME STEM TELEOSTS. Lettie C. Lawrence & Michael L. Fine, Dept. of Biol., Virginia Commonwealth Univ., Richmond VA 23284-2012. The teleost swimbladder functions in respiration and buoyancy and has evolved adaptations for hearing and sound production. Alosid herrings are extreme auditory specialists that can hear ultrasounds, aided by connections from the swimbladder to the ear. However, similar connections occur in nonalosid herrings without this ability. We describe the structure and material properties of two alosids, the American shad *Alosa sapidissima* and the blueback *Alosa aestivalis*, that hear sonic (0.2 kHz) to ultrasonic frequencies (180 kHz). We examined the gizzard shad *Dorosoma cepedianum* as an out-group in the clupeid family that cannot hear ultrasounds and the rainbow trout *Oncorhynchus mykiss*, an auditory generalist without auditory connections. All these species have transparent to translucent swimbladders. Picro-Ponceau and Weigert Iron Hematoxylin, and Verhoeff Elastin stains indicate swimbladders are composed of collagen but not elastin. Circular fibers have a greater thickness throughout the swimbladder in *A. sapidissima* and *A. aestivalis,* but *D. cepedianum* and *O. mykiss* have few circular fibers but well-developed longitudinal fibers in the tunica externa. *O. mykiss* swimbladders have a higher toughness and Young's Modulus and are stronger than in clupeids. The circular fibers of the alosids exhibit the greatest strain at break and could aid auditory function and allow for swimbladder expansion under greater pressure in deep water.

SCALING OF PECTORAL MUSCLES OF VIRGINIA CATFISHES. Joseph P. Miano & Michael L. Fine, Dept. of Biol., Virginia Commonwealth Univ., Richmond, VA 23284-2012. The muscles of the pectoral spine in ictalurid catfishes are the spine abductor, the arrector dorsalis, the arrector ventralis, and the spine adductor. We examined the scaling of these muscles as a function of both body weight and percent body weight in *Ictalurus furcatus* (blue catfish), *Ameiurus catus* (white catfish), and *Pylodictis olivaris* (flathead catfish). Percent muscle weight in blue catfish increased non-linearly, with larger fish having proportionately smaller muscles, for all muscles but the arrector ventralis, which maintained linear growth. In flathead catfish only the spine adductor grew non-linearly, and all muscles in white catfish exhibited linear growth. Both the spine abductor and spine adductor were larger than the arrector dorsalis and arrector ventralis in all species. The spine abductor and spine adductor are responsible for large amplitude movements, and the arrector dorsalis and arrector ventralis have more specialized functions in spine elevation. The percent size of the spine abductor, spine adductor, and arrector dorsalis is similar in blue and white catfish. Abductor and adductor muscles were larger in blue catfish than in flathead catfish, but the arrector dorsalis and arrector ventralis were similar. All white catfish muscles, except for the arrector ventralis, were proportionately larger than in flathead catfish muscles.

OVER-WINTER CAGE CULTURE OF BROWN TROUT (*Salmo trutta*). Scott H. Newton and Edward N. Sismour, Virginia State University Agriculture Research Station, Petersburg, Virginia 23806. Three cages of brown trout (*Salmo trutta*) were reared alongside three cages of rainbow trout in a comparison trial during from fall 2007 to spring 2008. This was the second research attempt to cage rear brown trout in Virginia. During the first attempt (early 1990s), brown trout failed to survive in cages in a Nottoway County farm pond when water temperature began to fluctuate during April. In the present study, brown trout survival was high (> 98%) in two cages but very poor (73%) in a third cage due to irregular feeding activity that led to cannibalism. Overall, brown trout survival was only 75% compared with 98% for rainbow trout. Brown trout growth was less than rainbows with harvest weights averaging two ounces less than rainbow trout. Brown trout production is risky due to the predaceous and cannibalistic nature of this species. Also, another natural factor is their growth phase begins at a larger size than is normally considered compatible with caged fish culture. Unless there is a very specific marketing reason, brown trout is not a good commercial cage culture candidate.

FISH HEALTH PROBLEMS FROM CAGE-REARED CATFISH FINGERLINGS FOLLOWING TRANSPORT David Crosby[1] and Edward N. Sismour[2] [1]Virginia Cooperative Extension, Virginia State University, PO Box 9081, Petersburg, VA 23806; [2]Agriculture Research Station, PO Box 9061, Virginia State University, VA 23806. Transport of catfish purchased from out-of-state producers can require in excess of 20 hours causing stress on fingerlings. This study examined short-term (3-week) survival of catfish following transport and stocking into cages. Fish were

delivered in June and September, 2007. Sixty fish were randomly sampled at initial stocking (Week 0) and at weekly intervals for three weeks post-stocking to assess the prevalence of parasites of the skin and gills. Catfish were free of clinical signs of diseases at the initial stockings, while gills of several of the June catfish (5%) indicated that Proliferative Gill Disease had been present. In June, fish started to die from external Columnaris within two days of the initial stocking and ESC was also recovered from these fish. Gill worms (Ligictaluridus) and Henneguya cysts were observed at Week 0 and Ichthyophthirius multifiliis (Ich) was present at Week 2 for both groups. Ich was observed among 18% of June fish and among 83% of September fish. Ich was no longer observed by Week 3 of the June study but was still present by the end of the September study. Total mortality was approximately 50% for the June group, whereas there was no significant mortality for the September group. It appears that the spring fingerlings were subject to more environmental and handling stress compared to the fall fingerlings.

LOW SALINITY PRODUCTION OF COBIA *RACHYCENTRON CANADUM.* Brendan C. Delbos, D Russell, MH Schwarz, SR Craig, & E Mclean, VSAREC, Hampton, VA 23669. With the anticipated growth of domestic cobia aquaculture, alternative production techniques are being explored to facilitate the farming of this species in an environmentally and economically sustainable manner. The Virginia Tech Aquaculture Research Group in collaboration with MariCal, an animal health and nutrition company, have been examining the feasibility of culturing cobia in recirculating aquaculture systems under low salinity conditions. Implementation of this technology would allow the siting of production facilities away from delicate coastal ecosystems to inland areas. In addition, inland low salinity production effluent would be amenable to traditional municipal waste water treatment. During 2005 and 2006 two trials were conducted evaluating the effects of various ion ratios in water and diets on production of juvenile cobia under low salinity conditions. For trial I, a total of 240 fish (mean weight of 25.5g) were randomly assigned to one of two salinity treatments (20ppt and seawater diluted to 3ppt). Six iso-caloric diets with various ion additions were then randomly assigned to the low salinity treatment while a single control diet was fed to fish in the higher salinity treatment. For trial II, 240 test fish (mean weight of 41.9 g) were randomly assigned to one of three salinity treatments (equivalent to 1.8, 2.5 and 20ppt using proprietary salt blends) and one of four dietary treatments and acclimated to testing conditions over a two week period. Results from both trials indicate that although growth and feed efficiency were significantly reduced, cobia can be cultured as low as 2.5ppt without a significant decrease in survival. Furthermore, no significant differences among dietary treatments were identified at the lower salinities.

POND PREPARATION FOR STOCKING THE FRESHWATER SHRIMP (*MACROBRACHIUM ROSENBERGII*). Brian L. Nerrie. Virginia Cooperative Extension, Virginia State Univ., Petersburg, VA 23806. Alternative crops are being examined in the tobacco growing region of Virginia. One such crop is the tropical

freshwater shrimp, *Macrobrachium rosenbergii*. Juvenile shrimp (0.5 g) are stocked in prepared ponds in late May when water temperature exceeds 20°C at a density of 20,000-50,000/ha. Natural pond foods and supplemental feed provides the nutrients for excellent growth. Decreasing water temperature dictates harvest in late September or early October of 30-45 g shrimp (800-1200 kg/ha). Appropriate pond preparation before stocking is essential for production success. Water quality management, soil conditioning, and sufficient fertilization to stimulate natural foods are required for success. Pond soil is limed to increase water alkalinity >50 ppm. Screened inflowing water limits the introduction of predators. Organic fertilizers such as alfalfa meal or pellets are applied two weeks before stocking at a rate of 250 kg/ha to establish zooplankton, aquatic worms and insect larva. High phosphorus inorganic fertilization encourages phytoplankton which is consumed by zooplankton.

SURVIVAL AND GROWTH COMPARISONS OF SPRING- VERSUS FALL-STOCKED CATFISH FINGERLINGS IN CAGES OVER WINTER. Edward N. Sismour & Scott H. Newton, Virginia State University Agricultural Research Station, Petersburg, Virginia 23806. Channel catfish (*Ictalurus punctatus*), an important fishery resource in Virginia, are regularly imported from southern states because of high demand. Fingerling purchases in the fall may be a better option for some producers. This study evaluated growth and survival of catfish fingerlings in cages over winter. The hypothesis that smaller, fall-stocked fish would exhibit reduced growth and survival compared to larger, spring-stocked fish was not supported. Two groups of catfish, one purchased and stocked in cages in mid-June, 2007 and the other in mid-September, 2007 were compared. Fish from each group were restocked into cages in mid-October, 2007. For each group, three cages were stocked with 215 fingerlings that were weighed (gm) and measured for total length (cm) at both stocking and harvest. Fish were fed a standard ration when winter pond water temperature exceeded 10 °C. Both groups had high survival, only four spring catfish died. Increase in length was not significantly statistically for spring catfish and was marginally significant for fall catfish. Weight increase in both groups was significant statistically and was greater proportionally for fall catfish. Feeding efficiency did not differ statistically. The practical significance of this study is that farmers could purchase fingerlings in the fall as water temperature decreases, possibly at lower cost and with minimal cost for feed to hold the fish over winter. This strategy would contribute to reduction of stress associated with transport and stocking in the spring and would help maximize production because fish would be in cages at the onset of the growing season.

WATER QUALITY FROM MULTI-BATCHING CATFISH PRODUCTON PONDS IN VIRGINIA. David Crosby. Cooperative Extension VSU, PO Box 9081, Petersburg, VA 23806. Multi-batching catfish production project was initiated to simulate seine through water shed ponds in June of 2005. Five ¼ acre ponds were stocked with catfish weighting 55 lbs. /1000 fish. Catfish were stocked at 5000 fish

per acre. Fish were fed to satiation from Monday through Friday. One of the project objectives was to monitor and collect water quality data from June to September. The average daily feeding of catfish ranged from 40 lbs to 60 lbs of feed per day during this part of the study. Water samples were collected from 2005 to 2007 for each pond once-a-week in the afternoon before 3 pm. Water quality parameters tested included pH, TAN, and Nitrite. All parameter levels were typical for this type of catfish production system. The hardness and alkalinity ranged from 34 to 51 ppm. The pH ranged from 6.0 to 10.0 for all ponds. TAN were below 2.5 ppm for the entire study. Nitrites were consistently below 0.25 ppm. However, some ponds did spike to nearly 1 ppm. Ponds with nitrite spikes were treated with salt. The overall water quality (TAN and Nitrite) for the first three years was considered very acceptable for this type of catfish production system.

CHANGING PATTERNS OF ANTHELMINTIC USAGE AND RESISTANCE IN VA SMALL RUMINANT INDUSTRIES. Joseph P Tritschler, Michaela PL Dismann, & Brian L Sayre, VA Coop Ext, VSU, Vet Sci, Chesterfield Tech Center, & Dept Biol, VSU. By combining producer data, on-farm Fecal Egg Count Reduction tests and *in vitro* larval development assays, a detailed status of anthelminitc resistance on 20 representative Virginia small ruminant farms was generated. Data covered 2002-08. Modern anthelmintics represent only three pharmacological classes: benzimidazoles (BZ), levamisole/morantel (LM) and macrocyclic lactones (ML). In general, once resistance develops to any drug in the class, cross-resistance will rapid be expressed to the complete class. Several critical trends were noted. BZ resistance approached 100% of farms. For LM class, morantel was resistant on 67-95% and the more effective levamisole showed 40-75% failure. For ML class, ivermectin (IVE) resistance approached 100% of farms, and the newer moxidectin (MOX) showed 40-70% failure. MOX demonstrated a dramatic time effect, showing only marginal signs of resistance in 2002-03 data and almost complete failure in limited 2007-08 data. It is estimated that 33-50% of Virginia farms no longer have any effective anthelmintic, BZ and IVE are resistant on over 90% of farms, 20-25% have one effective anthelmintic (LEV or MOX) and less than 10% have both LEV and MOX still effective. Future strategies relying heavily on anthelmitics will fail. The authors gratefully acknowledge the help of the Veterinary Science program at Chesterfield Technical Center.

OILSEED FLAX AND HUMAN HEALTH Harbans L. Bhardwaj and Anwar A. Hamama, Agricultural Research Station, Virginia State University, Petersburg, VA 23806. Oilseed flax (*Linum usitatssimum* L., Family Linaceae) has gained recognition as a functional food i.e. it provides health benefits beyond what is expected from its traditional nutritional content. Oilseed flax oil is a rich source of α-linolenic acid (also known as Alpha Linolenic Acid; 18:3n-3; Omega-3 fatty acid). Higher 18:3 content is desirable for human nutrition. Canada is the largest producer and exporter of flax in the world. Efforts are on-going at Virginia State

University to evaluate potential of oilseed flax, as an alternative crop, We studied the oil content and quality of seed from five oilseed flax cultivars () grown at Petersburg and Suffolk during 2003-04 crop season. Flax seed contained to 42.3 percent oil which contained 47.8 and 18.9 percent linolenic and linoleic fatty acids, respectively. The ratio of Omega-3 to Omega-6 fatty acids in flax oil was 2.5 indicating that flax oil is healthy for human consumption. It was concluded that flax have potential as new crops in Virginia to provide healthy oils for human consumption. On-going field research includes experiments at three Virginia locations (Orange, Petersburg, and Suffolk) to determine optimal planting time, productivity, and oil traits. Faculty and staff volunteers from Virginia State University are participating in a study to determine effects of consuming 30 g ground whole flaxseed daily for 12 weeks on blood traits.

PHOTOSYNTHETIC RESPONSE OF GREENHOUSE TOMATOES TO DIFFERENT TEMPERATURES AND CO_2 CONCENTRATIONS UNCER LOW WINTER LIGHT CONDITIONS. Mark Kraemer & Françoise Favi, Agricultural Research Station, Virginia State University, Petersburg, VA 23806. Winter production of greenhouse tomatoes in the mid-Atlantic region is constrained by low light intensity. Periods of cloudy weather in late winter and spring , when tomato plants are in full production, have often led to stress induced problems such as blossom drop and susceptibility to disease. To reduce these problems we used a portable photosynthetic meter (Licor 6400) to determine the photosynthetic rate of leaves in a producing greenhouse, at different temperatures, light intensities, and CO_2 concentrations. Higher temperatures resulted in higher photosynthetic rates when light intensities were above 100 PAR, but reduced photosynthetic rates when lower. High CO_2 concentrations (1200 ppm) resulted in greater photosynthesis (40-60%) at all temperatures up to 89 °F. These results indicate that temperatures in tomato greenhouses should be reduced during periods of low light intensity to below 65 °F and CO_2 should be enhanced if possible.

COMPARISON OF THREE TYPES OF SOILESS MEDIA FOR PRODUCTION OF GREENHOUSE TOMATOES IN VIRGINIA. Christopher D. Mullins, Cooperative Extension, Virginia State Univ., Petersburg VA. 23806. While rockwool is the primary root substrate used in greenhouse tomato production, most small growers in Virginia prefer using peat-based media in vertical five gallon bags. However, growing concerns about the non-renewable nature of sphagnum peat moss and rising prices of peat-based media has growers looking for other types of media for tomato production. A two year study of effect of media type on yield of greenhouse tomatoes was started in fall 2006. Peat-based media, coconut coir, and perlite were compared as root substrates for production of greenhouse tomatoes. Tomato cultivar 'Trust' was grown in all three media types in plots of three plants with each media treatment replicated seven times. Irrigation and fertigation were the same for all plants. No significant difference was found in marketable yield or

fruit size in year 1. Any of these substrates would be suitable for tomato production. Cost, availability, ease of use, and other benefits should be considered driving factor in grower's decision concerning media type.

ALLELOPATHIC REACTIONS GENERATED BY *VERNONIA GALAMENSIS* (VGA) AERIAL PART. Francoise D. Favi & Mark Kraemer. Agricultural Research Service, Virginia State University Petersburg VA 23806. VGA pappus transports mature achne as parachutes by wind into new territory and contain both sesquiterpenes and triterpenes. We use bioassays and light microscope to assess allelopathic effects of these chemicals on soybean seedlings. Pappus chemicals significantly (DF = 3, F = 74.20 and P> 0.0001) prevent damping-off diseases of both VGA and soybean seedlings at first stage of germination. Ten-day old soybean seedlings were significantly rotten (DF = 3, F = 6.53 and P> 0.0152) or bent due to weaken stem. Light microscope of thick sections of the treated seedling stem showed disorganized parenchyma cells compared to the control.

Astronomy, Mathematics and Physics and Materials Science

FACTORING SECOND DEGREE POLYNOMIALS OVER THE INTEGERS: MOTIVATING SECONDARY SCHOOL TEACHERS TO LEARN PROOF TECHNIQUES. Sherrie N. Mitchell & Boyd Coan, Dept. of Mathematics, Norfolk State Univ., Norfolk, VA 23504. Traditionally, secondary school instructors are taught many different techniques for making elementary algebra and arithmetic more palatable to the layman meeting these mathematical ideas for the first time. However, it is rare if ever, that the opportunity is available to illustrate the duality between research and teaching. To do research and develop original techniques and methods in mathematics, it is helpful to learn how to construct, write and read mathematical proofs. This in turn leads to improved teaching. Presenting mathematical proof techniques to the layman in an effective algorithmic manner remains elusive. Polya's four-step problem solving process provides a novel approach to the efforts to make it more a science than an art, to motivate secondary school teachers to learn proof techniques. Factoring second-degree polynomials over the integers is used as an example of a proof based project

PROPOSED METHOD FOR PLASMA-TREATED NANOCOMPOSITE THIN FILMS AS A AU METAL ADHESION LAYER FOR POLYMER SUBSTRATES. [1]Bruno J. Caputo, [2]Ethan Rosenthal, [1]Christopher Hughes & [2]Brian Augustine. [1]Dept. of Physics and Astron., and [2]Dept. of Chemistry, James Madison Univ., Harrisonburg, VA 22801. This project is focused on chemically adhering a metal to a polymer substrate. Using Polymethyl Methacrylate (PMMA) slides, the nanocomposite polymer poly[(propylmethacryl-heptaisobutyl polyhedral oligomeric

silsequioxane)-co-(methylmethacrylate)] (POSS-PMMA) can be spuncoat onto the PMMA slide and then plasma etched. A glass-like layer forms on the surface opening up the POSS cages allowing for better adhesion for gold films and better protection of the PMMA during chemical processes. The process uses an electron beam deposition method and adhesion tests are to be conducted using chemicals such as Methyl Methacrylate, hexane, tetrahydrofuran (THF), isopropyl alcohol, and water. Afterwards, the adhesive properties will be measured using an Atomic Force Microscope (AFM) and a Scanning Electron Microscope (SEM).

GENERATION OF ASYMPTOTICALLY CONVERGENT APPROXIMATIONS FROM DIVERGENT PARKER SOCHACKI EXPANSIONS. Joseph D. Rudmin, Integrated Science and Technology Dept., James Madison Univ., Harrisonburg VA 22807. Several years ago Drs. Ed Parker and James Sochacki published a remarkably efficient general algorithm to generate the Taylor series solution to any system of differential equations. When this Taylor series is divergent, one would like to generate a convergent representation. Presented here is a general algorithm to convert any divergent Taylor series to a ratio of two asymptotically convergent polynomials. This algorithm is an extension of a simple and general algorithm to obtain a ratio of two integers, which approximates an irrational number, and uses the minimum number of digits in the ratio for a specified precision.

INFRARED SPECTROSCOPY OF HOLMIUM DOPED KPb_2Cl_5 FOR LASER APPLICATIONS. O. Oyebola[1], E. Brown[1], U. Hommerich[1] & S. Trivedi[2], [1]Dept. of Physics, Hampton Univ., VA 23668 and [2]Brimrose Corporation of America, Baltimore, MD 21236. The optical properties of rare earth doped potassium lead chloride (KPb_2Cl_5) continue to be of current interest for applications in infrared (IR) solid-state gain media. In contrast to many other halides, KPb_2Cl_5 is non-hygroscopic, which makes it an attractive host material for solid-state lasers. The narrow phonon spectrum of KPb_2Cl_5 extends to only ~200cm^{-1}, which leads to small non-radiative decay rates through multi-phonon processes. In this work, we present the infrared emission properties of Ho^{3+} doped KPb_2Cl_5 and evaluate its potential as a novel IR gain medium. Following optical excitation at 885nm, several IR emission bands were observed with center wavelengths at 1063nm, 1172nm, 1333nm, 1655nm 2886nm and 3900nm. Further spectroscopic studies were focused on the mid-IR emission at 3900nm arising from the Ho^{3+} transition $^5I_5 \rightarrow {}^5I_6$. The emission lifetime of the $^5I_5$ level was measured to be 4.9ms at room-temperature and remained nearly constant when cooling the sample to 15K. the nearly temperature independent lifetime is consistent with a small non-radiative decay rate for the $^5I_5$ excited state of Ho^{3+} as predicted by the energy-gap law.

NEAR INFRARED EMISSION PROPERTIES OF Er:YAG CERAMIC, Er KPb_2Cl_5, AND Er:KPb_2BR_5 FOR 1.5-1.6μm EYE-SAFE SOLID STATE LASERS. C. Hanley[1], E. Brown[1], U. Hömmerich[1], S. Trivedi[1], [1] Dept. of Physics, Hampton Univ., Hampton VA 23668 and [2]Brimrose Corporation of America, Baltimore MD 21236. There exist a significant current interest in the development of a new generation of long-wavelength eye-safe bulk solid-state lasers with resonance diode laser pumping. Applications of laser sources that operate in the eye-safe wavelength regime near 1.5-1.6μm include remote sensing, ranging and material processing, long distance telemetry, and optical communications. Eye-safe laser wavelengths can be achieved by using trivalent Er^{3+}, a rare –earth ion that has an emission transition at ~1.5 μm Er^{3+}. Trivalent erbium Er^{3+} ($4f^{11}$) has been considered an important activator ion in many infrared solid-state lasers. For eye-safe laser operation Er:YAG continues to be the main material under consideration. In this investigation other materials were evaluated as potential gain media for the 1.5 μm spectral region including ceramic Er:YAG, Er KPb_2Cl_5, and Er:KPb_2BR_5. Results of a comparative spectroscopic study of these materials will be presented at the conference including infrared absorption and emission studies, lifetime measurements and calculation of 1.5 μm transition cross section.

PRELIMINARY STUDIES OF A PLANAR TRANSFORMER. Gregory A. Topasna & Daniela M. Topasna, Dept. of Physics and Astronomy, Virginia Military Institute, Lexington VA 24450. We present the preliminary results of a planar transformer consisting of a straight wire that is flux linked to a rectangular loop. Our calculations indicate a linear relationship between the input and output voltages that is frequency dependent. Electrical characterization of this transformer also shows linear voltage dependence that is consistent with our calculations at low frequencies.

NUMERICAL SIMULATION OF FIBER SEDIMENTATION IN NAVIER-STOKES FLOWS. J. Wang, Dept. of Mathematics and Statistics, Old Dominion Univ., Norfolk, VA 23529 & A. Layton, Dept. of Mathematics, Duke Univ., Durham, NC 27708. Many physical and biological applications involve the dynamics of a large number of fibers immersed in a viscous fluid. It is of significant importance to accurately predict the behavior of the fiber-fluid interactions. We perform a study on this problem by formulating a computational hydrodynamic model based on the Navier-Stokes equations, and making use of a numerical technique known as the immersed boundary method. We discuss the effects of fiber shapes, fluid viscosities and physical boundaries on the behavior of the fiber suspension and sedimentation.

POWER BASIC CONSOLE COMPILER—A POWERFUL COMPILER FOR PROGRAMMING TECHNICAL APPLICATIONS IN WINDOWS. Joseph W.

Rudmin, Dept. of Physics and Astron., James Madison Univ., Harrisonburg VA 22807. The Power Basic Console Compiler is a Basic Language compiler with a structure similar to the language C. It generates high-speed stand-alone executable programs which work in the 32-bit Microsoft Windows operating system. It requires structured programming, and works well with Microsoft Software. It permits object oriented programming, and has many advantages over other programming systems. This talk gives a history of technical programming languages and discusses the pros and cons of each language.

ASTRONOMICAL OBSERVATIONS WITH A THERMOMETER. Thomas C. Mosca III, Dept. of Mathematics, Rappahannock Community College, 52 Campus Drive, Warsaw, VA. 22572. Spring, summer, fall, and winter are formally defined as the intervals between the solar equinoxes and solstices. The dates and times of the seasonal endpoints are determined astronomically. A less formal determination can be made using temperature. Spring and fall are periods during which temperature changes rapidly, and almost linearly. Summer and winter are the periods in between, during which temperature changes less rapidly, peaks, and the direction of change reverses. Mean daily water temperatures from 1954 until 2001, measured at Gloucester Point, Va. are used to graphically illustrate the four seasons, and the equinoxes and solstices are approximately located. Water temperature data were provided by Virginia Institute of Marine Science, Gloucester Point, VA. 23062.

QUARKNET AT HAMPTON UNIV. Kenneth Cecire & Donald Whitney, Dept. of Physics, Hampton Univ., Hampton VA 23668. Hampton Univ. has been involved with QuarkNet (http://quarknet.fnal.gov) since 1999 as the home base of one of the five QuarkNet staff members in the U.S. and since 2000 as a QuarkNet center. QuarkNet is a national program, funded by DOE and NSF, to bring particle physics into high schools. Thus the Hampton Univ. QuarkNet center consists of Hampton Univ. physicists, staff, and a cadre of Virginia high school physics teachers. With the support of the Hampton Univ. Center for the study of the Origin and Structure of Matter, this group has been involved in various local, nationwide, and global projects: cosmic ray detectors and the QuarkNet cosmic ray e-Lab (http://quarknet.fnal.gov/grid), the international particle physics Masterclass, support for a Virtual QuarkNet Center online, a student blog dedicated to the Large Hadron Colider at CERN, a teacher-led series of physics workshops for elementary school teachers (http://cosm.hamptonu.edu/~kcecire/pie/pie.html) in collaboration with Jefferson Lab, and mutual support as a group of like-minded physics teachers. Many of these initiatives have an online home at and can be accessed through a wiki on the COSM server at http://cosm.hamptonu.edu/vlhc. A small-to-medium-sized Univ. can have a significant impact on science education through a combination of components like these; emphases on exciting science research, bringing teachers into scientific collaborations, and teachers helping teachers can be combined with

provision of online resources to not only affect the local community but also to have an extended global impact.

Biology and Microbiology

EXPLORATION OF PHYTOPLANKTON COMMUNITIES IN SOUTHEASTERN VIRGINIA FOR USE IN BIODIESEL PRODUCTION. Todd A. Egerton[1], Nathan A. Bowman[1], Robert J. Johnson[1], Mathew R. Semcheski[1], Harold G. Marshall[1], Zhanfei Liu[2], Adair Johnson[2], Rachael Cooper[2] & Patrick Hatcher[2], [1]Dept. of Biological Sciences and [2]Dept. of Chemistry and Biochemistry, Old Dominion University, Norfolk VA 23529. A survey of thirty-nine freshwater and estuarine habitats in Tidewater Virginia was conducted to examine the capability of local phytoplankton populations for biodiesel production. Over 120 algal taxa were identified during the study, including several genera that have been previously noted as having potential biodiesel applications. Cyanobacteria were the dominant phytoplankton group at the majority of stations, however these locations generally had lower levels of fatty acid methyl esters (FAME). Samples containing higher abundances of chlorophytes, diatoms, and dinoflagellates had the highest percentages of FAME. The results of this initial study indicate that this region supports diverse phytoplankton communities including those that are potential sources of fatty acids needed to produce biodiesel. This study is a component of the Virginia Coastal Energy Research Consortium.

THE SUPERIOR PREDATORY HABITS OF ALLOSAURUS IN JURASSIC NORTH AMERICA, Jamie Stearns & Robert K. Rose, Dept. of Biological Sciences, Old Dominion University, Norfolk, VA 23529. Although the Morrison Formation of Late Jurassic North America contains many genera of carnivorous dinosaurs, one genus, Allosaurus, accounts for almost three-quarters of all finds of these predators. Based on previous studies of predatory habits of this genus and others, it appears likely that Allosaurus dominated the ecosystem due to specialized hunting adaptations, including strong arms with a good grappling ability and a specialized bite for hunting giant herbivores. Paleoenvironmental evidence from sites in Wyoming supports this conclusion.

A PHYLOGENY OF THE SNAPPERS (LUTJANIDAE; PERCOIDEI) INFERRED FROM CYTOCHROME B SEQUENCE DATA. Matthew R. Semcheski & Kent E. Carpenter, Department of Biological Sciences, Old Dominion University, Norfolk, VA 23529. The Lutjanidae are the economically and ecologically important fishes commonly known as snappers. Early studies of Lutjanidae concluded that it contained four subfamilies. Together with the family Caesionidae, the lutjanids formed the Superfamily Lutjanoidea. Although this view was supported elsewhere

in the literature, it was later contradicted, treating the caesionids as members of the Lutjanidae. Further investigations revealed complications within the subfamily Lutjaninae. In order to infer a phylogeny of genera within Lutjanidae, the complete cytochrome b gene (1140bp) of 21 lutjanid taxa was sequenced and analyzed along with 19 sequences obtained from GenBank. Analyses included base composition, saturation analysis, maximum parsimony (MP), maximum likelihood (ML), and Bayesian inference (BI). Substitutions increased linearly with sequence divergence. MP analysis failed to resolve relationships at the subfamily level. ML and BI analyses resolved monophyletic Etelinae, Apsilinae, and Paradicichthyinae subfamilies within Lutjanidae. MP, ML, and BI analyses grouped the caesionids within the subfamily Lutjaninae, most closely related to *Macolor niger*. Results illustrate a close relationship between caesionid and lutjanid taxa. However, the placement of caesionids in the Lutjanidae remains unresolved as they fall out within Lutjaninae, rendering this subfamily paraphyletic. All analyses place Paradicichthyinae as basal, rather than Etelinae. Relationships among genera within Lutjaninae remain unresolved, with the genus *Lutjanus* paraphyletic.

ELECTRICAL AND OLFACTORY DETECTION OF PREY BY THE YELLOW-SPOTTED STINGRAY, *UROBATIS JAMAICENSIS*. Mallory J. Offner & Soraya M. Bartol, Dept. of Biol., Virginia Wesleyan College, Norfolk VA 23502. There have been several studies conducted investigating the use of electroreception in elasmobranchs, particularly concerning prey capture. However, research involving the comparison of multiple senses is lacking. I set out to compare the behavioral responses of the yellow-spotted stingray, *Urobatis jamaicensis*, to odor and electrical stimuli through a variety of food sources. The stingray's response time was recorded during four sets of trials using live prey (both odor and electric), dead prey (odor only), electrodes (electric only), and dead prey combined with electrodes (odor and electric). When response times are compared between the odor and electrode trials, the stingray exhibited a stronger response towards the odor. If the trials using both the odor and electrical stimuli are included, the stingray reacted more strongly when it could utilize both senses. From these data, it appears that the animal is capable of using either stimulus for prey finding behavior, however, further research needs to be conducted on multiple specimens to determine statistically if one stimulus is preferential over the other. There is potential for this research to have practical applications, as humans and elasmobranchs often interact, especially regarding fisheries (to attract or repel certain species) and animal husbandry in aquarium settings.

EFFECTS OF PREDATION RISK, DENSITY AND DISEASE ON ENERGY EFFICIENCY IN A LARVAL ANURAN. Sarah Crane & J. Vonesh, Dept. of Biol., Virginia Commonwealth Univ., Richmond, VA, 23284. Predation, density and disease affect behavior, morphology and growth. There is a lack of information on how these changes relate to efficiency of energy transfer in anuran larvae,

although previous studies suggest that predation should decrease and competition should increase efficiency. Using a 2 x 2 factorial design, I manipulated predation presence and larval density to test how predation risk and density affect energy efficiency. During the experiment, approximately half of the tadpoles were infected by an unknown disease. Neither predation risk nor density affected assimilation or growth efficiency, despite changes in growth and development. Disease, however, decreased gut length and growth efficiency. This study builds on past work on the effects of predation and density on a larval amphibian, but also introduces disease as another factor. My study suggests that disease may be at least as important if not more important than predation or density in regards to growth efficiency.

DIFFERENTIAL APPETITE-RELATED RESPONSES TO CENTRAL NEUROPEPTIDE S IN LINES OF CHICKENS DIVERGENTLY SELECTED FOR LOW OR HIGH BODY WEIGHT. Brian Prall, Wendy Calchary, Paul Siegel & Mark Cline, Department of Biology, Radford University, Radford, VA 24142. The anorexigenic 20 amino acid neuropeptide S (NPS) has not been studied in an animal model of hypo- or hyperphagia. Our study was designed to elucidate if central NPS appetite-related effects are different in lines of chickens that had undergone long-term divergent selection for low (LWS) or high (HWS) body weight and are hypo- and hyperphagic respectively. It took a longer time for food intake to be reduced in LWS than HWS chicks administered the lowest dose of NPS tested (0.14 nmol) and at the highest dose tested (0.56 nmol) they had a greater reduction in food intake than did HWS chicks. HWS chicks responded with a similar magnitude of food intake reduction that was independent of NPS dose. Although water intake was reduced concurrently with food intake after central NPS in both lines, blood glucose concentrations were not affected. Hypothalamic signalling was different between the lines. Although both lines respond to central NPS with decreased c-Fos immunoreactivity in the lateral hypothalamus, the periventricular nucleus had increased c-Fos immunoreactivity in LWS but not HWS chicks. After central NPS treatment there was increased c-Fos immunoreactivity in the paraventricular nucleus in HWS but not LWS chicks. These data support the notion of differences in the central NPS system between the LWS and HWS lines and infer that central NPS may differentially affect appetite-related processes in other species that contain hypo- and hyperphagic individuals.

SHORT-TERM ANOREXIGENIC EFFECTS OF CENTRAL NEUROPEPTIDE VF ARE ASSOCIATED WITH HYPOTHALAMIC CHANGES IN CHICKS. Wendy Calchary, Christie Bowden, Jessica Layne & Mark Cline, Department of Biology, Radford University Radford, VA 24142. The study reported here was designed to measure feed and water intake, changes in hypothalamic chemistry, and other behaviour modifications after central injection of NPVF in broiler type chicks. In Experiment 1, chicks responded to central NPVF with a reduction in feed intake for up to 90 min post injection. Water intake was not affected. In Experiment 2,

neuropeptide VF exerted a less potent and shorter duration of attenuated feed intake than did the structurally related neuropeptide FF. In Experiment 3, 16.0 nmol NPVF reversed prolactin releasing peptide (PrRP) induced orexigenic effect. In Experiment 4, central NPVF treatment was associated with decreased c-Fos immunoreactivity in the lateral hypothalamus (LH), while c-Fos immunoreactivity in the dorsomedial nucleus, infundibular nucleus (homologue to the mammalian arcuate nucleus) and ventromedial nucleus was increased. In Experiment 5, behaviours unrelated to ingestion including sit, stand, deep rest and locomotion were affected by central NPVF injection. Some of these behaviours are incompatible with ingestion and may contribute to hypothalamic associated perception of satiety after central NPVF. In conclusion, NVPF is a short term regulator of appetite and its effects are associated with hypothalamic and behaviour changes in chicks.

USE OF SNIP-MAPPING TO FIND THE GENE RESPONSIBLE FOR A CELL CYCLE EXIT MUTANT IN *C. ELEGANS*. Lataisia Jones & Glenn C. Harris, Dept. of Biology, Virginia State University, Petersburg, VA 23806. Non-insulin dependant diabetes mellitus (NIDDM) is one of the most significant chronic human diseases, affecting over 20 million people in the United States (7% of the population). The goal of this project is to identify the gene responsible for a cell cycle exit mutant previously identified in the nematode *Caenorhabditis elegans*. We proposed to accomplish this by isolating multiple recombinant strains containing the gene and using single nucleotide polymorphism (SNiP) analysis to estimate the physical distance of the mutant gene from a known landmark, the unc-101 gene. Our findings to date suggest the gene is located within a 0.6 Mb region of chromosome 1. This effort demonstrates the effectiveness of using a PCR and restriction enzyme-based methodology to localize SNiPs within the *C. elegans* genome.

EXPRESSION OF CAMK-II SPLICE VARIANTS IN ZEBRAFISH VARIANTS IN ZEBRAFISH EMBRYONIC HEART. L Francescatto, S. Rothschild, & R. M. Tombes, Department of Biology, Virginia Commonwealth University, Richmond, VA, 23284. Calcium Calmodulin Kinase II (CaMK-II) is a serine/threonine protein kinase that alters key substrates by phosphorylation throughout the cell. In zebrafish, CaMK-II is encoded by at least seven genes: alpha, beta1, beta2, gamma1, gamma2, delta1 and delta2 (α1, β1, β2, γ1, γ2, δ1, δ2). Different CaMK-II probes were used in zebrafish embryos and have demonstrated the temporal presence of three genes β1, β2, and αKAP. Among these genes, β2 has been found to be essential for the looping of the heart during development, while others are expressed in the heart but no further studies have been performed to discover their roles in heart development. CaMK-II contains a catalytic, variable, and association domain. The genetic sequence of CaMK-II varies depending on the combination of exons which contribute to the formation of different splice variants. At least 25 splice variants are present during zebrafish development. As a result of this alternative splicing, the

transcribed protein products may have different roles in the physiology and development of the organism. Therefore, it is of extreme importance to determine which splice variants are present in zebrafish heart. The presence of different exons can possibly help to understand the role that this protein is playing during zebrafish embryonic development. We identified two CaMK-II genes, β1, and β2, that encode splice variants present in the zebrafish heart at 48 hpf. Each splice variant includes either exon II and VII, or exon II, III, and VII. Both of these splice variants are found in the CaMK-II β1 gene, while only the splice variant containing exon II and VII is found in the CaMK-II β2 gene.

CHEMOTROPISM IN NEUROSPORA CRASSA. Philip Rock, Virginia Wesleyan College, Norfolk, VA 23502. Understanding the growth of filamentous fungi as an organized mycelial entity remains a major challenge in biology. The chemotrophic response of *Neurospora crassa* was investigated using an inert growth medium composed from polyacrylamide. A standard 10% acrylamide/bis-acrylamide solution (prepared in deionized water) was poured into petri dishes and allowed to polymerize. Wells were made in the center and periphery of the dish using a cork borer. Spores suspended in minimal sucrose media placed in the central well grew radially outwards in a symmetrical manner. Spores inoculated into the central well of dishes that had 50 microliters of 20X minimal media solution in the peripheral well, grew asymmetrically towards the nutrient well (positive chemotropism). Among a number of mutant strains examined, an actin mutant of *Neurospora* failed to exhibit such positive chemotropism. This supports a model of organized hyphal growth requiring microfilaments made from intact actin subunits. The polyacrylamide chemotropism assay may be useful in identifying additional mutants defective in the chemotrophic response and in elucidating the mechanisms of mycelial growth and chemotrophism in *N. crassa*.

SOURCES OF MORTALITY IN VOLUNTEER PINE TREES. Robert K. Rose & Jay Kiser, Dept. of Biological Sciences, Old Dominion University, Norfolk, VA 23529. Since December 2002, small mammals have been captured, marked, and released on an oldfield study grid in southern Chesapeake. Starting in summer 2004, we noticed dead pine trees, all of which, when inspected, had been killed by girdling. From February to April, 2005, an assistant and RKR assessed the extent of pine mortality caused by rodents, primarily hispid cotton rats, *Sigmodon hispidus*. We counted 15,409 pines > 0.8 m tall in an area of 1.266 ha. Of these, 2025 had been completely girdled within the past year or two, and a further 305 were killed by fresh girdling during the time of our assessments, making mortality by rodents 15.1% of pines. A further 50.0% of pines had been partially girdled and 26 pines were dead by natural causes. This unusual eating of pine bark coincided with a high density of 130-140 cotton rats per hectare. Three years later, we observed high levels of natural mortality and relatively little mortality due to girdling, so we obtained the numbers using the same methods on the same area: 16,756 pines > 0.8

m tall, 137 (0.8%) dead by girdling, and 3846 (23.0%) dead by natural mortality. A high correlation (r = -0.995) indicated that natural mortality was greatest where pine density was greatest.

DISPERSION AND ORIENTATION OF CHINESE MANTID EGG CASES IN A PINE-DOMINATED OLDFIELD. A. Scott Bellows[1] & Robert K. Rose[2], [1]REMSA, 124 West Queens Way, Hampton, Virginia 23669, [2]Department of Biological Sciences, Old Dominion University, Norfolk, Virginia 23529-0266. The Chinese mantis, *Tenodera aridifolia sinensis*, is a univoltine tritrophic predator of oldfields. In three years of study of a population in eastern Virginia, we observed several unusual features in this introduced insect. More than 90% of egg cases were deposited in shrubs and trees, many at heights > 2 m. Egg cases were non-randomly oriented (to the south), but with no significant association between compass orientation and days to hatching of young. Egg cases were uniformly dispersed but least dense in open patches, the opposite of expectation for an oldfield insect. Smaller egg cases yielding fewer, later-hatching, but not lighter young when oriented towards the south. Together these features suggest that some females produce > 1 egg case, with later egg cases being smaller and with fewer eggs because of reduced food with which to make eggs, and are oriented to the south for greater metabolic efficiencies when the sun is moving progressively lower in the horizon in autumn. The result is temporal as well as spatial dispersion of hatchlings in spring.

SPOTTED SEATROUT AND THE ENVIRONMENT: THE STABLE ISOTOPE LINK. Reneé Reilly[1], Cynthia M. Jones[1], Robert F. Dias[2], & William E. Thompson[1]. [1]Center for Quantitative Fisheries Ecology, Old Dominion University, Norfolk, VA 23259 [2]Department of Chemistry and Biochemistry, Old Dominion University, Norfolk, VA 23529. Seagrass beds are commonly referred to as nursery habitats for juvenile fish, but the direct value of seagrass habitat to fisheries has not been directly quantified. Defining the link between juvenile fish fitness and the quality of the habitat in which they live is an integral part of quantifying the value of seagrass-nursery habitats. To examine this relationship, we are investigating the influence of carbon (C) and nitrogen (N) sources on juvenile fish growth over a three year period (2006-2008). To conduct this research, we chose the tightly coupled system of juvenile spotted seatrout (*Cynoscion nebulosus*) in lower Chesapeake Bay seagrass beds. We analyze stable isotopes in the water to evaluate C and N sources, while analyzing C and N in the fish muscle tissue as indicators of trophic structure. We will subsequently track the survival of these fish as part of our NSF funded spotted seatrout mortality research. Our preliminary results show significant differences in the stable isotope signatures of spotted seatrout in our three different sampling zones in the Chesapeake Bay. While our study will continue through 2008, we already have evidence that demonstrates how various C and N sources in seagrass habitats are reflected through the trophic levels, as dietary

components are assimilated into fish muscle tissue. With further evidence we hope to demonstrate the value of seagrass nurseries and provide a method for quantifying those areas with the most productive conditions for fish growth and subsequent survival.

PROVIDING QUANTITATIVE METRICS FOR MARGINAL INCREMENT ANALYSIS (MIA) TO VALIDATE ANNULUS FORMATION. C. Morgan[1], N. Prista[2] & C. M. Jones[1], [1]Center for Quantitative Fisheries Ecology, Old Dominion University, Norfolk, VA 23508, [2]Centro de Oceanografia, Faculdade de Ciências da Universidade de Lisboa, Campo Grande, 1749-016 Lisboa, Portugal. Fish ages are typically determined by counting growth rings ("annuli") in calcified structures such as otoliths. For ages to be accurate, the periodicity of annuli deposition must be validated. The most common method for validating periodicity in annulus formation is Marginal Increment Analysis (MIA). To this date, MIA interpretations have relied on subjective graphical interpretations and a sound statistical background has never been given to this validation technique. In this study, we perform a first-ever application of statistical time-series analyses to marginal increment data, using spot (*Leiostomus xanthurus*) otoliths as a case study. Using the periodogram and seasonal-trend decomposition based on loess, we successfully identify an annual periodicity in spot annuli, as well as a decreasing trend in mean marginal increment size and a slight shift in the seasonality of annulus deposition through ages. We conclude that these methods of time-series analysis provide a reliable statistical framework for MIA application and suggest their generalized application in MIA of calcified structures.

METAGONIMOIDES OREGONENSIS (CLASS: TREMATODA) INFECTION IN LARVAL AMPHIBIANS. Lauren R. Fischer & Lisa K. Belden, Department of Biological Sciences, Virginia Tech, Blacksburg, VA 24061. There are approximately 24,000 species of parasitic trematodes (flatworms) in the world. Yet aside from the few species that directly infect humans or livestock, we know very little about most of them. Most trematodes have complex life cycles involving multiple host species. The species that is the focus of our research is *Metagonimoides oregonensis*, which uses raccoons as definitive hosts, where sexual reproduction occurs, and stream snails and amphibians as intermediate hosts. Some variation regarding the life-cycle has been noted for populations in the western vs. eastern U.S. Our study objective was to begin exploring the impact of *M. oregonensis* infection on second intermediate host amphibians. We experimentally examined the ability of *M. oregonensis* cercariae from North Carolina to infect *Rana* spp. tadpoles, but did not see any evidence of infection. We also examined infection rates in larval stream-dwelling salamanders, *Desmognathus quadramaculatus* and compared the number of visible cysts on live animals versus the total number of cysts identifiable after clearing and staining. There is a strong correlation between these variables, which will allow us to study infection dynamics

in natural salamander populations over time. Our other future plans include sequencing of *M. oregonensis* across the entire species range, establishing its life cycle in the laboratory, and continued monitoring of amphibian infection rates.

EXAMINING LINKS BETWEEN WATER QUALITY AND STRESS HORMONES IN EASTERN SPOTTED NEWTS. Kristen M. Scheller, Kim S. Kirkbride, David L. Chambers, Ignacio T. Moore & Lisa K. Belden, Department of Biological Sciences, Virginia Tech, Blacksburg, VA 24061. The population declines and range reductions experienced by amphibians in the past decades have led to questions concerning the causes of these declines. In addition to natural population fluctuations, several anthropogenic factors are being considered, some of which include alterations in water quality. This project examined the correlation between the physiological stress response, as measured by circulating levels of the hormone corticosterone, and pond water quality among several populations of Eastern spotted newts (*Notophthalmus viridescens*) in Southwestern Virginia. Both baseline and stress-induced (30 min confinement) blood samples were collected in the field (n=6-7 newts/site, 5 sites) and analyzed for corticosterone levels using radioimmunoassay. Dissolved oxygen and pH measurements of the five ponds included in the project were taken in the field. Corticosterone levels were significantly elevated following the 30 min confinement. In addition, the response to confinement varied among sites, with individuals in one population seemingly unable to mount a stress response with confinement. This suggests this population is not living in optimal conditions. Further research is needed to determine what factors contribute to the variation of the stress response between sites.

CENTRAL CALCITONIN GENE RELATED PEPTIDE CAUSES HYPOTHALAMIC ASSOCIATED ANORECTIC RESPONSES IN *GALLUS GALLUS*. Wendy Calchary & Mark Cline Department of Biology, Radford University, Radford, VA 24142. Calcitonin gene-related peptide (CGRP), consisting of 37 residues, is found in the gastrointestinal tract and causes reduced feed intake in mammals. Its effects in the avian class are unreported. We found that intraceberoventricular (ICV) injection of CGRP caused a linear decrease in feed and water intake in Cobb-500 chicks. We determined that the effect on water intake was secondary to feed since feed-restricted chicks did not have reduced water intake. Next, we found that an intaperitonal (IP) injection of CGRP reduced feed intake, but did not affect water intake. In order to determine if the hypothalamus was associated with these affects we examined c-Fos immnoreactivity in several key appetite-related nuclei. Both ICV and IP CGRP caused activation of paraventricular, periventricular and ventromedial hypothalamic nuclei, the homolog of the mammalian arcuate nucleus. The results demonstrated that CGRP causes anorexigenic effect in chicks and the hypothalamus is involved.

CENTRAL CALCITONIN CAUSES ANOREXIGENIC EFFECTS IN CHICKS. Jessica Layne & Mark Cline Department of Biology, Radford University, Radford, VA 24142. Plasma concentration of calcitonin is increased following a meal. In mammals, peripheral and central calcitonin reduce feed intake. However, to our knowledge its effects in birds are unreported. Through a series of experiments we have found that central calcitonin lowers feed intake in broiler-type chicks but does not effect water intake. Calcitonin-treated chicks also responded with decreased feed pecks while other behaviors (exploratory pecks, jumps, defecations, locomotion and the amount of time spent standing, sitting, perching or in deep rest) were not affected by treatment. Calcitonin-treated chicks had increased pecking efficiency. Finally, c-Fos immunoreactivity was quantified in classically appetite-related hypothalamic nuclei. Calcitonin increased reactivity in the arcuate nucleus, dorsomedial nucleus and ventromedial hypothalamus; nuclei that are associated with satiety perception. These data support that satiety after central calcitonin is likely primarily hypothalamic in origin and not secondary to activation of some other behavior.

OSMOTIC FRAGILITY OF LIPOSOMES. Danielle Neal & Stephen Gallik, Department of Biological Sciences, University of Mary Washington, Fredericksburg VA 22401. The goal of the research project described here is to develop a simple spectrophotometric assay, similar to the classic red blood cell osmotic fragility test, that could be used to study the short-term and long-term stability of cell-size liposomes. The specific objectives of this research project are two-fold: a) to identify a suitable non-toxic marker that can be encapsulated in cell-size liposomes and that can be detected with visible-light spectrophotometry, and b) to identify the optimum wavelength of light to be used to detect the release of the marker upon liposome lysis. Liposomes were generated using a simple rotary evaporation procedure in which phosphatidylcholine, chloroform, methanol, and an aqueous solution containing a candidate marker were added to a round bottom flask. Rotary vacuum evaporation over a two-minute period removed the organic phase, during which time liposomes formed. Samples from each product were evaluated with a light microscope and digitally photographed. Attempts to encapsulate crude isolates of hemoglobin from sheep red blood cells, a seemingly ideal candidate marker, failed. The massive amounts of debris that accumulated in the product suggests that protein denaturation and aggregation perhaps occurred. Attempts to encapsulate an alternative marker, common red food dye, which contains the nontoxic pigment allura red AC, were successful. Spectrophotometric analysis of osmotically-induced lysis of lipsomes containing red food dye showed that wavelengths of visible light between 450nm and 480nm and between 580nm and 620nm could be used to monitor the release of the marker during liposome lysis.

CHARACTERIZATION OF A NATURALLY OCCURING ARTEMISININ RESISTANT *PLASMODIUM FALCIPARUM* CLONE. Ghislaine Mayer &

Maimuna Bruce, Dept. of Chemistry, Virginia Commonwealth University, Richmond, VA, 23284. Malaria has been a prevailing health problem in many countries around the world and is caused by protozoan parasites from the genus *Plasmodium.* One such protozoan is *Plasmodium falciparum,* one of the most widespread protozoan parasites causing malaria in humans. The *Plasmodium* life cycle contains four blood stages, the ring, trophozoite, schizont, and gametocyte, which is the precursor to the sexual stage that mosquitoes are able to transmit. Due to its health impact, there have been numerous anti-malarial drugs on the market to combat the effects of this disease. Some strains of *P. falciparum* have developed resistance to these drugs such as Dd2Nm and FCR3, while others have remained sensitive such as HB3. Artemisinin, or qinghaosu, is a native Chinese drug, derived from the herb *Artemisia annua.* It has been used against chloroquine-resistant and sensitive strains of *P. falciparum,* and is known to be effective at a low nanomolar concentration. Its usefulness has been shown to increase when combined with other synthesized anti-malarial drugs. Because of its short half life, resistance is thought not to happen readily.

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Botany

CORRELATIONS BETWEEN PLANT COMMUNITY AND WATER TABLE PARAMETERS: A NEW PERSPECTIVE ON OLD FIELD SUCCESSION. Krista C. Sweet, Herman W. Hudson & Robert B. Atkinson, Center for Wetland Conservation, Dept. of Biology, Chemistry and Environmental Science, Christopher Newport University. In the United States, destruction of wetlands requires a permit, which may require wetland replacement often involving restoration of lands that were drained for agriculture. The federal manual for wetland delineation provides some of the success criteria for mitigation sites, and uses plant dominance to assess vegetation and, for hydrology, evidence of inundation or saturation to within 30 cm of the soil surface for a minimum of 5% of the growing season. The purpose of this study was to evaluate the use of a prevalence index for the plant community by comparison to water table parameters in a proposed mitigation site. Correlation between plant community and water table parameters were analyzed in a 6.5 ha (16.2 ac) former agricultural field in Mathews County, VA prior to its restoration. Fifteen PVC pipe wells were hand augered to an approximate depth of 1m. The wells were then sealed, surveyed, and sampled weekly from March through August 2007. In August 2007, plant community dominance was evaluated in three 1-m^2 subplots adjacent to each well. The relative cover and indicator status of each species (obtained from the USDA Region 1 Plant List) in each plot were used to calculate a prevalence index. A linear regression was then performed on the mean

prevalence index of each plot versus the percentage of inundation or saturation during the growing season and results were negatively related (r^2=0.38, $P < 0.05$). Based on the vegetation prevalence index at the site, nearly half of the site may come to support wetland communities even if no hydrologic modification is attempted. Results suggest that a prevalence index may be used to assess restoration potential in some agriculture fields.

ROLE OF FLORISTIC QUALITY INDEX IN UNDERSTANDING PLANT COMMUNITY DEVELOPMENT IN RESTORED WETLANDS. Jessica M. Campo, Jackie D. Roquemore & Robert B. Atkinson, Center for Wetland Conservation, Dept. of Biology, Chemistry and Environmental Science, Christopher Newport University. Establishment of appropriate wetland vegetation is a common objective in restoration but sometimes difficult to achieve. In summer 2007, six wetland compensation sites of the Virginia Aquatic Resource Trust Fund were investigated. The VARTF focuses site selection on wetland restoration areas within targeted corridors. Sites ranged in age from 3 to 7 years post construction and were 1.8 ha to 49.4 ha in size. Using a class system to estimate colonizing vegetation cover (dominance), we analyzed species richness, conservation values (C-values), and Floristic Quality Index (FQI) values in 501 randomly established 1-m^2 plots. The number of species per plot averaged 6.4 (SE +/-0.36, range 5.3 – 7.6) and the number of species per site averaged 62 (SE +/-6.6, range 42 – 89). C-values were based on the Virginia Wetland Plants C-Value List and represent a species likelihood of occurrence in pristine versus disturbed sites. Based on a 0-10 scale, the average C-value per site was 3.0 (SE +/-0.27, range 2.7 – 3.2). Our estimates of high species richness, low average C-values and low FQI values are similar to those reported in the literature for young restored sites and likely represent a colonization phase in early site development. The dominance of native species may result from favorable site selection practices that (1) prioritize wetland restoration over creation and (2) identify natural corridors in an effort to restore ecological integrity at the landscape scale.

PLANT COMMUNITIES IN RESTORED NONTIDAL WETLANDS: THE RELEVANCE OF CYPERACEAE, JUNCACEAE AND POACEAE. Jackie D. Roquemore, Brittany A. Chilton & Robert B. Atkinson, Center for Wetland Conservation, Dept. of Biology, Chemistry and Environmental Science, Christopher Newport University, Newport News VA 23606. Current state and federal policies require that wetlands lost to development be replaced by restoration, creation, or similar activities. Monitoring of replacement wetlands typically focuses on establishment of hydrophytic plant communities. However, newly restored or created wetlands are colonized by a floristically diverse assemblage often including taxonomically challenging graminoids (families Cyperaceae, Juncaceae and Poaceae). In this study of eight restored non-tidal wetlands in Virginia herbaceous species were censused within 636 randomly selected 1-m^2 plots. The dominance

and richness of Cyperaceae, Juncaceae and Poaceae were quantified. An average of 19.25 +/- 4.7 graminoids were identified and 72% of these species were hydrophytes. Results suggest that misidentification or other errors associated with this group could lead to mischaracterization of successful wetland replacement.

POTENTIALLY HARMFUL PHYTOPLANKTON WITHIN VIRGINIA TIDAL TRIBUTARIES: BLOOM AND TOXIN PRODUCERS. Harold G. Marshall, Todd Egerton, Robert Johnson, Matthew Semcheski & Nathan Bowman. Dept. of Biological Sciences, Old Dominion University, Norfolk, VA 23529-0266. Monitoring phytoplankton populations since 1985 has provided us significant data regarding their composition, distribution, abundance, and bloom development within Virginia tributaries and the Chesapeake Bay. These include a variety of non-toxic bloom producers. However, of 38 potentially harmful species identified, *Microcystis aeruginosa, Karlodinium veneficum,* and *Cochlodinium polykrikoides* are currently among other taxa as common bloom producers within Virginia tributaries and there are indications of their increasing presence and expanding range of development. Major blooms of *M. aeruginosa* occur annually in the Potomac R., extending into oligo-mesohaline regions with concentrations reaching 10^5 cells ml^{-1}, and often accompanied by high levels of microcystin. In recent years blooms (10^5 cells ml^{-1}) of the toxin-producing *K. veneficum* have also occurred in the Potomac R. system, and we have verified its presence in other Virginia rivers at lower concentrations. Over the past decade the range and bloom development of *C. polykrikoides* has increased to becoming a major annual bloom producer (10^3 cells ml^{-1}) in rivers along the southwestern shoreline of Chesapeake Bay, including the Virginia Beach ocean front. In summary, algal blooms are common events in these waters, responding to favorable environmental conditions of temperatures, salinity and nutrient levels. Among these bloom producers are potentially harmful species. Supported by the Virginia Department of Environmental Quality and the Virginia Department of Health.

PRE- AND POST-HURRICANE COMPOSITION IN A HARDWOOD FOREST. Kjärstin A. Carlson-Drexler & Stewart A. Ware, Dept. of Biology, College of William and Mary, Williamsburg, VA, 23185. On September 18, 2003, Hurricane Isabel passed over Williamsburg, Virginia. This storm produced a multi-hectare microburst in the College Woods of the College of William and Mary in Williamsburg, Virginia. No salvage logging occurred in the damaged areas, leaving trees where they fell during the storm. In 2006, permanent plots were set up in the microburst and surrounding intact forest ("reference"), and tree species and size were recorded for all individuals larger than 5 cm diameter at breast height (1.4 m). Trees were placed into several damage categories, and were classified as "lost" if they were snapped off or otherwise below breast high. Chi-square and Fisher's Exact analyses were performed on damage and loss values for each species in each area. In the microburst area, *Quercus rubra* lost significantly more individuals and

experienced more damage than expected, while *Ilex opaca* lost significantly fewer individuals and experienced less damage than expected. In the reference area, no species lost significantly more or fewer individuals than expected. These results show that following a disturbance, composition reconstruction is possible even without pre-disturbance plots, as long as salvage logging does not take place. Additionally, pre-disturbance reconstruction may provide a more valuable comparison to post-disturbance composition than does nearby, less disturbed habitat.

ADAPTATION TO SOIL TYPE IN ROCK OUTCROPS: *CROTONOPSIS ELLIPTICA* AND *CROTON MONANTHOGYNUS*. Stewart A. Ware, Dept. of Biology, Coll. of William and Mary, Williamsburg,VA 23187-8795. In eastern North America where rock is at or near the soil surface and trees are excluded, herbaceous plants dominate the vegetation. Extreme summer drought, wintertime soil saturation, and extreme soil chemistry exclude many common open-area weeds. As a result, especially adapted endemic species characterize the shallow soil flora of rock outcrop areas. However, a few widespread weeds do occur in the shallow soil zones, such as *Crotonopis elliptica,* present only on sandstone and other acidic outcrops, and *Croton monanthogynus*, abundant on limestone. To determine whether *Crotonopsis* was excluded from limestone outcrops by soil type intolerance or by competition from *Croton*, each species was grown experimentally in a greenhouse in its own and the other's soil type. *Crotonopsis* was greatly inhibited by limestone soil (growth reduced by 75%) and looked sickly. C*roton* grew less well on sandstone than on limestone (reduced by 25%), but plants looked healthy. *Crotonopsis* is no doubt excluded from limestone outcrops by soil type intolerance, while *Croton* may be unimportant on sandstone outcrops because of its mild intolerance or, more likely, a weakened competitive ability on sandstone. The work was done in part at the University of Arkansas, supported by a Faculty Research Grant from the College of William and Mary.

HERBARIUM SPECIMENS AS ART: ANATOMY OF AN EXHIBITION. W. John Hayden, Dept. of Biology, Univ. of Richmond, 23173. Planning, development and implementation of an exhibition titled "Native Plants of Virginia: Selections from the University of Richmond Herbarium" is described. Planning was initiated by University Museum staff and the herbarium curator at the University of Richmond in June 2005 for an exhibition focused on Virginia native plants as part of Jamestown commemoration events of 2007. An early vision featured species displayed via an herbarium specimen, a photograph of the plant from nature, and a line drawing, with each element of the display given more or less equal prominence. As the exhibit developed, herbarium specimens received greater and greater emphasis, perhaps because of their novelty as art objects. Line drawings were the work of L. C. Gastinger (produced for the upcoming *Flora of Virginia*) and were retained for approximately one third of the species displayed. Photographs (by W.

J. Hayden) were reduced to mere thumbnail images on display legends (known as "chat labels"). Display legends provided formal scientific and common names and touched on various aspects of the biology of the plants featured: morphology, ecology, pollination mechanisms, and utility to humans were common themes. Also, as appropriate, legends featured curatorial information about the specimens, label data, collectors, annotations, etc. Opening of the exhibit was marked by a "gallery talk" titled "From Flower to Flora: The Nuts and Bolts of Floristic Botany" which endeavored to explain the role of herbarium specimens in the study of flora (the plants in nature) and the production of floras (books about plants). Later, during the run of the exhibition, artist L. C. Gastinger conducted a botanical illustration workshop. The exhibit was open to the public February 28 to July 13, 2007 during which time it was viewed by 1745 people who, it is hoped, learned something about native plants, botanical field work, herbaria and floras while also enjoying the aesthetic qualities of well-prepared herbarium specimens.

THE GENUS *BISCHOFIA* BLUME (PHYLLANTHACEAE/EUPHORBIACEAE), ADVENTIVE IN NORTH AMERICA. W. John Hayden, Dept. of Biology, Univ. of Richmond, 23173. Relationships, morphology, native and adventive US ranges, and possible ecological threats posed by *Bischofia javanica* are reviewed as a contribution towards the eventual treatment of Euphorbiaceae *sensu lato* in the Flora of North America project. *Bischofia* has traditionally been classified in Euphorbiaceae subfamily Phyllanthoideae, which is now recognized as family Phyllanthaceae. Two species are known but only *Bischofia javanica*, native to regions from India and China, to the Phillipines, Australia, and Melanesia, occurs in North America. *Bischofia javanica* has been cultivated for decades in Florida, as far north as Alachua County. The tree is now naturalized in coastal counties of Florida from Sarasota to Cape Canaveral. *Bischofia* has been planted rarely in southern California where it shows no sign of naturalizing. The plants are dioecious trees with pinnately trifoliolate leaves. Staminate flowers are produced in large panicles; each is minute, with five imbricate sepals, five stamens and a central 5-angled pistillode. Pistillate inflorescences are also paniculate; each flower consists of a 3-carpellate gynoecium surrounded by 5 free sepals. Fruits are drupaceous, typically bearing six ecarunculate seeds (two per carpel). Commonly known as Bishop Wood, *Bischofia javanica* was once promoted as a street tree, but its propensity to outgrow small residential lots, to develop irregular canopies with age, to host numerous leaf-spot diseases and insect pests, coupled with its invasive tendencies, now make it undesirable. Nevertheless *Bischofia javanica* appears to be a well-established element of Florida's naturalized flora.

NATIVE AND ADVENTIVE SPECIES OF *MANIHOT* MILL. (EUPHORBIACEAE) IN NORTH AMERICA. W. John Hayden, Dept. of Biology, Univ. of Richmond, 23173. Species of the genus *Manihot* in North America north of Mexico are under study as a component of the eventual treatment

of Euphorbiaceae in the Flora of North America project. A total of six species occur within the continental US; four are native and two cultivated species show varying degrees of becoming naturalized. Southern Arizona hosts two hemicryptophyte species: *M. davisiae*, characterized by broad pandurate leaf lobes and *M. angustiloba*, characterized by narrow, linear, leaf lobes and spinose tips; both of these species range widely to the south in Mexico. Southern Texas has two species: *M. subspicata*, a low shrub with terminal inflorescences and smooth fruits and *M. walkerae*, a hemicryptophyte with axillary inflorescences and verrucose/rugose fruits. *Manihot walkerae* is globally rare. Both Texas species also occur in nearby regions of Mexico. *Manihot grahamii*, native from southeast Brazil to northern Argentina is frost tolerant; stems die to the ground in winter but rejuvenate robustly in the spring. *Manihot grahamii* can be cultivated outdoors as far north as Raleigh, North Carolina and it is naturalized sporadically throughout the Gulf coast region. *Manihot esculenta*, the source of manioca and tapioca, native to tropical America and now cultivated throughout the tropics, is occasionally cultivated in frost-free areas along the Gulf coast where it may escape to a limited extent; it can be recognized by its robust shrubby habit, swollen nodes, and entire-lobed leaves with glaucous/reticulate undersurfaces.

THE *FLORA OF VIRGINIA* PROJECT: A 2007-2008 UPDATE. Marion B. Lobstein, Dept. of Biology, Northern Virginia C.C., Manassas, VA 22205. Virginia, for its landmass, has the most diversity of vascular plant species of any state in the United States. It had the first flora, the *Flora Virginica* in 1743, yet does not have a modern flora. The Virginia Academy of Science for over eighty years has supported efforts to produce a modern *Flora of Virginia.* In 2001 the Foundation of the *Flora of Virginia*, Inc, was formed in 2001 and in May 2002 received 501(c) 3 status. Progress continues to be made on the efforts to develop a *Flora of Virginia* including fund-raising and public outreach efforts. Work on the content of the *Flora of Virginia*, including nearly 300 of the core illustrations, has been commissioned, completed, and funded by VAS funds. An $80,000 grant from the Virginia Environmental Endowment Fund is available to support development of *The Flora of Virginia.* The Academy, including the Fellows, continues to provide essential support, including financial support, for this Project. Other progress includes completion of treatments of the dichotomous keys of 155 of the 201 vascular plant families in Virginia and the first step in developing species and genus descriptions has been completed. The second step of herbarium work on descriptions is 53% complete, and the third and final step of species and genus descriptions is 40% completed. The projected publication date is late 2011 or early 2012.

NATURAL HISTORY OF HAWAIIAN PLANTS: USING MOLECULAR DATA TO UNRAVEL ISLAND EVOLUTION. Timothy J. Motley, The J. Robert Stiffler Professor of Botany, Dept. of Biological Sciences, Old Dominion University,

Norfolk, VA 23529-0266. The Hawaiian Islands are the most isolated archipelago in the world. Because they are volcanic and formed as the Pacific tectonic plate moved over a hotspot in the Earth's crust, the islands have never been in contact with any other land mass. All life on Hawaii has arrived via long distance dispersal. These colonizers, if successful, found open habitat niches, relaxation of selective pressures, and reductions in competition and reproductive barriers which many organisms exploited. Sherwin Carlquist in his famous books *Island Life* and *Island Biology* documented many adaptations common among island organisms, e.g., gigantism, loss of dispersal, insular woodiness, and adaptive radiation. The fauna of the islands have given rise to flightless flies, no-eyed, big-eyed spiders, and an extinct 2 m tall goose. The flora also has become one of the most extraordinary in the world, and includes: the silverswords; giant, Seussian lobelias; tree-sized spurges and bluets; unscented, fleshy-fruited mints; and woody violets and plantagos. Recent molecular systematics studies have investigated some of these novel morphological adaptations, the geographical origins of many of these lineages, and tested the theories of island evolution. This paper will discuss the recent insights from molecular plant systematics and provide a photographic overview of the spectacular Natural History of the Hawaiian Islands.

BOTANICAL RESEARCH IN THE GALÁPAGOS ISLANDS - PRIORITIZING FUTURE STUDIES. Conley K. McMullen, Dept. of Biology, James Madison University, Harrisonburg VA 22807 & Alan Tye, South Pacific Environment Programme, Samoa. The Galápagos Islands, made famous after Charles Darwin's visit in 1835, have a long and varied history of botanical exploration and research. Since the establishment of the Charles Darwin Foundation in 1959, the Charles Darwin Research Station in 1964, and the Galápagos National Park Service in 1968, a tremendous amount of botanical research has been accomplished through the collaborative efforts of these organizations, visiting scientists, and local and international volunteers. The direction of this research has often been determined by the council of various experts who have, from time to time, met to discuss and prioritize the various areas and needs of botanical studies in the archipelago. In this presentation, we discuss the major emphases of previous botanical studies in the islands and list our recommendations of crucial areas of botanical research needing to be addressed in the upcoming years.

ANTIOXIDANT ACTIVITY IN SELECTED DOMESTIC AND IMPORTED WINES. Lindsay E. Deliman & Michael H. Renfroe, Dept. of Biology, James Madison University., Harrisonburg VA 22801. A strong correlation has been reported between disease prevention and antioxidants. Wine is one source of antioxidants in many human diets. The type of grape, fermentation and processing of wines, and vineyard location are all factors that may lead to variations in antioxidant content of wines. For example, red wines include the grape skins, a strong source of antioxidants, throughout the entire process while white and rosé do

not. By testing the antioxidant activity in fourteen various wines from the regions of California, Australia, and North Carolina, differences were noted about their antioxidant content. The antioxidant activity was measured by using the ABTS/H_2O_2/HRP decoloration method. Trolox, a well characterized and stable antioxidant, was used as a comparative standard for wine antioxidants. The highest antioxidant contents were found to be in an Australian shiraz, with a mean of 16.90 µmol TE (Trolox equivalents) /ml, and Californian merlot, with a mean of 14.66 µmol TE/ml. The second highest antioxidant content resided in North Carolina muscadine-based red wine, which had a mean of 5.50 µml TE/ml. A Californian white zinfandel had a mean of 1.44 µmol TE/ml, which is lower than the Australian chardonnay, which had a mean of 1.72 µmol TE/ml. These means display the increase in the antioxidant content in red wines from white wines. The wines with the least color, such as a white or rosé, generally contained the least concentration of antioxidants. Results indicate that wines vary greatly in their antioxidant content.

HYDROPHILIC ANTIOXIDANT ACTIVITY IN BREWED COMMERCIAL TEAS. Michael H. Renfroe, Kaitlyn Watson, Leena Khan & Anna Dinh, Dept. of Biology, James Madison Univ., Harrisonburg, VA 22807. Teas are consumed as part of healthy diets in part due to the presence of antioxidants which are thought to help prevent various chronic diseases and provide multiple health benefits. We analyzed the antioxidant content of various black, oolong, green, and white teas prepared from *Camellia sinensis*. We also analyzed a variety of herbal teas. Antioxidant content was measured using the ABTS/H_2O_2/HRP decoloration method, and means were compared using a one-way analysis of variance followed by Dunnett's T3 test for significance of differences of means. We sampled five black teas, three oolong teas, seven green teas, one white tea, and five herbal teas including peppermint (*Mentha piperita*) and boldo (*Peumus boldus*). Antioxidant content varied widely among teas. There was significant lot-to-lot variation within a given brand of tea as well as brand-to-brand statistically significant differences. Antioxidant content varied from 27 to 704 µmol trolox equivalents/g fw of tea. Variability of antioxidant content among teas suggests that further studies should be conducted to determine the sources of variation. These results also indicate that antioxidant testing should be more extensively repeated with a variety of samples and that results should be reported as ranges rather than as absolute values. Studies of antioxidant content in brewed beverages can provide information helpful to planning healthy diets.

SCHOOL GROUND GARDENS IN THE CITY OF RICHMOND, VA. Leonard O. Morrow, volunteer. A pilot project of hands-on gardening has been initiated with 3 elementary schools and one technical high school in the City of Richmond. Raised beds and containers on solid surfaces, or landscape fabric, have been used to grow decorative and food plants with student/teacher involvement and SOL applications. Summer water supply is the most critical factor for survival of plants.

The urban gardens on public school grounds may benefit lessons leading to crime prevention, and is one response to the Nature Deficit Disorder phenomenon.

INVESTIGATIONS INTO VEGETATIVE PROPAGATION OF THE NATIVE SHRUB *SYMPLOCOS TINCTORIA* (L.) L'HÉR. (SYMPLOCACEAE). Dana R. Reynolds & Linda MK Johnson, Dept. of Biology, Chemistry and Environmental Science, Christopher Newport University, Newport News, VA 23606. Native plants are often difficult to locate for ornamental uses due to problems with or ignorance of effective propagation methods. We investigated the vegetative propagation of an underused understory shrub known as Horsesugar or Sweetleaf (*Symplocos tinctoria*). Using mid-summer, semi-hardwood straight and heel stem cuttings and applying different types of rooting hormones, we achieved the best rooting success with straight stem cuttings using Hormodin 3 and Dip 'N Grow 1000ppm rooting hormones.

DESIGNING A VISITOR-FRIENDLY CAMPUS ARBORETUM WEBSITE. Kenton A. F. Buck, Megan M. Hudson, Abigail C. Thomas, W. Tyler Warren & Linda MK Johnson, Dept. of Biology, Chemistry and Environmental Science, Christopher Newport University, Newport News, VA 23606. Cross-disciplinary projects require a well-defined set of goals as well as active collaborators willing to assume responsibility for their part of the workload. Our group's goal is to generate a website that allows visitors to explore and learn about the wonderful selection of plants installed on CNU's campus. In order to achieve this objective, we are enlisting campus experts in GIS-mapping, plant identification, and website development. This presentation illustrates the educational and web-graphic goals of the project as well as the coordination efforts required in the preliminary stages of this ambitious project.

Chemistry

UNDERSTANDING THE REACTIVITY OF EBSELEN USING SAPE AND DFT METHODS. Craig A. Bayse & Sonia Antony. Dept. of Chemistry and Biochemistry, Old Dominion University, Norfolk, VA 23539-0126. The reactivity of ebselen in biological system is computationally investigated using DFT method with the inclusion of (solvent assisted proton exchange) SAPE network. The activation energy is lowered with the use of SAPE network. The energy also varies with the number of water molecules used in the SAPE network.

CHARACTERIZATION OF A NATURALLY OCCURING ARTEMISININ RESISTANT *Plasmodium facliparum* CLONE. Ghislaine Mayer & Maimuna Bruce, Dept. of Chem. Virginia Commonwealth Univ. Richmond, VA 23284-2006. Malaria has been a prevailing health problem in many countries around the world and is caused by protozoan parasites from the genus *Plasmodium*1. One such protozoan is *Plasmodium falciparum,* one of the most widespread protozoan parasite causing malaria in humans. The *Plasmodium* life cycle contains four blood stages, the ring, trophozoite, schizont, and gametocyte, which is the precursor to the sexual stage that mosquitoes are able to transmit. Due to its health impact, there have been numerous anti-malarial drugs on the market to combat the effects of this disease3. Some strains of *P. falciparum* have developed resistance to these drugs such as Dd2Nm and FCR3, while others have remained sensitive such as HB3. Artemisinin, or qinghaosu, is a native Chinese drug, derived from the herb *Artemisia annua.* It has been used against chloroquine-resistant and sensitive strains of *Plasmodium falciparum,* and is known to be effective at a low nanomolar concentration. Its usefulness has been shown to increase when combined with other synthesized anti-malarial drugs4.Because of its short half life, resistance is thought not to happen readily.

NUCLEOPHILIC SUBSTITUTION MECHANISMS – TRANSITION STATES. Charles M. Bump, Department of Chemistry, Hampton University, Hampton, VA 23668, The purpose of this work is to examine nucleophilic substitution reactions in order to better understand and differentiate between S_N1 and S_N2 type reaction mechanisms. Semi-empirical (AM1) transition states were generated for nucleophilic substitution reactions (gas phase) reactions of alkyl halides using MOPAC. The influence of nucleophile and leaving group as well as the structure of the substrate (methyl, ethyl, isopropyl, sec-butyl, tert-butyl) will be discussed.

INVESTIGATING THE BASIS OF NATURAL ORGANIC MATTER PHOTOCHEMISTRY. Amy K. Carfagno &. Charles M. Sharpless, Dept. of Chem., University of Mary Washington, 1301 College Avenue , Fredericksburg, VA 22401. In natural waters, absorption of sunlight by natural organic matter (NOM) results in production of reactive oxygen species such as singlet oxygen ($^1O_2$) and hydrogen peroxide (H_2O_2). The proposed reaction pathway involves interaction of excited state NOM (NOM*) with molecular O_2. Energy transfer from NOM* to O_2 forms the highly reactive singlet oxygen ($^1O_2$); NOM* may also reduce O_2, producing O_2^-, which dismutates to H_2O_2. The absorbance spectra of NOM are characterized by the E2/E3 ratio, the absorbance at 254 nm divided by that at 365 nm. Previous research in our lab showed a strong positive linear correlation between the quantum yield of $^1O_2$ and E2/E3. The present project extends the research to H_2O_2 quantum yields. Our results indicate that lowering the E2/E3 ratio by increasing pH leads to higher H_2O_2 quantum yields. This seems to suggest that long-wavelength light absorption by NOM favors electron transfer to oxygen but

disfavors the kind of energy transfer that leads to $^1O_2$. Electrochemistry experiments were also conducted to gain insight into the link between NOM redox properties and photochemical reactivity; however, cyclic voltammograms of NOM solutions do not reveal distinct peaks above the background. The small, broad peaks that are observed may be overlapping multiple redox transitions of the diverse functional groups in NOM.

AQUEOUS NANOMATERIALS: SYNTHESIS, STABILITY, AND FILM GROWTH. R. Day, A. Galyean, C. Dowdy, & M. Leopold, Department of Chemistry, University of Richmond, Richmond VA 23173. Much interest exists in utilizing the unique properties of nanomaterials for improving the sensitivity and efficiency of biological and chemical sensors. Thin films of nanomaterials that can swell or contract in the presence of a specific analyte are currently being explored for this purpose. This report describes the successful design of thin, air-stable film assemblies comprised of aqueous gold nanoparticles with electrostatic-based, polymeric linking mechanisms. The films preserve the versatile properties of nanoparticles, including the ability to be easily functionalized, while incorporated into a flexible film – properties suggesting potential sensing applications such as metal ion detection in aqueous solution. Film growth dynamics and stability were assessed by the characterization of the film's surface plasmon band, which is dependent upon the inter-particle spacing and local environment of the nanoparticles within the film. The feasibility of incorporating other nanomaterials into these film systems, specifically hollow gold nanoshells, recently shown to exhibit an increased optical sensitivity to changes in its local environment, is also reported.

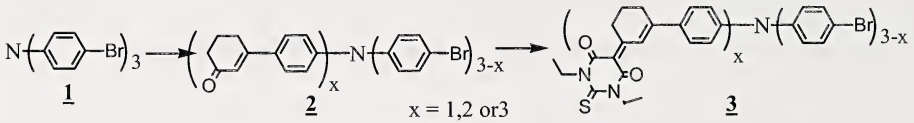
ADSORPTION OF NITRIC ACID ON BOEHMITE M.W. Ross and T.C. DeVore, Dept of Chem. And Biochem. MSC 4501, James Madison University, Harrisonburg VA 22807, Solid state Fourier transform infrared spectroscopy (FTIR), evolved gas analysis-FTIR (EGA-FTIR), thermal gravimetric analysis (TGA) and differential scanning calorimetry (DSC) were used to investigate the desorption of nitric acid from boehmite. Samples containing up to 36% adsorbed nitric acid by mass were prepared by placing the mineral in 70% nitric acid solution. FTIR established that water solvated nitrate was the main species adsorbed on the surface. The water solvated nitrate vaporized as nitric acid at ~ 400 K with an enthalpy of desorption of ~ 50 kJ/ mol. A second nitric acid desorption occurred at ~ 450 K and had an enthalpy of desorption of 85 kJ/ mol was assigned as desorption of partially solvated aluminum hydroxylated nitrate. Monodentate and bridging nitrate desorbed at ~ 725 K as NO_2 and O_2 with an enthalpy of reaction of ~ 55 kJ/ mole NO_2 desorbed.

SUBUNIT STRUCTURE OF THE CLONED HUMAN GUANINE-7-METHYLTRANSFERASE. Eliza A. Jacob, Jeanhee Chung, Austin T. Wray, &

Thomas O. Sitz, Dept. of Biochemistry, Virginia Tech, Blacksburg, VA 24061. The 5'-end of eukaryotic mRNA is capped and the guanine base is methylated in the N-7-position generating a fully functional cap structure. If the cap is not methylated at the N-7 position, the mRNA is not translated, i.e. this methylation is essential for gene expression. The non-methylated cap structure-RNA was produced by *in vitro* transcription with T7-RNA polymerase. This RNA was purified by gel electrophoresis and different size fractions were recovered. By isolating the lower molecular weight non-methylated capped RNA, we increased the overall yield by about 5 fold. The enzyme that methylates the N-7 position, Guanine-7-methyltransferase, has been expressed as a His-tag protein in *E. coli*. The addition of histidines at the N-terminus allows the enzyme to be purified on a Nickel column. The full length enzyme, 476 amino acids long, is about 80% pure after the nickel column. To further purify the enzyme, a positively charged ion-exchange column (Mono Q-Sepharose) was used. The elutant from the Nickel column was applied to the Mono-Q column and eluted with increasing concentrations of KCl. A major methyltransferase peak eluted at 0.1 and 0.15 M KCl and was over 95% pure as determined by SDS polyacrylamide electrophoresis. This purified guanine-7-methyltransferase was then applied to a FPLC-Superose 12 gel exclusion column to characterize the subunit structure. Two major peaks of protein and methyltransferase activity were observed which corresponded to about 90% homodimer and 10% monomer. We plan to study the deletion mutation (minus 120 amino acids) to see if the N-terminal region plays a role in subunit formation.

STATISTICALLY DESIGNED EXPERIMENTS: TOOLS FOR EDUCATION AND THE EXAMINATION OF REGIOCHEMISTRY OF ELECTROPHILIC AROMATIC SUBSTITUTIONS. J. A. Mann, Dept.of Chem./Physics and BES, Longwood University, Farmville, VA & G. P. Lutz , Prince Edwards County High School, Statistically designed experiments were developed and executed in order to determine the effects of several variables on the regiochemistry of electrophilic aromatic substitution (EAS) reactions. One experiment employed the electrophilic aromatic bromination of phenol, and indicated that temperature and concentration had statistically insignificant effects on the product composition of the reaction, while the mole ratio of bromine to phenol and percent water content of the solvent had significant effects at the 95% confidence level (i.e. =0.05). Another experiment investigated the Friedel-Crafts acylation of three butylbenzene isomers, and showed that temperature and reaction time had insignificant influences on product composition, while solvent dielectric constant and substrate substitution pattern had a significant influence (=0.05). Together these experiments suggest that chemometric methods may be useful in investigating even well understood reactions. The Friedel-Crafts acylation experiments also represent the initial stages in the development of a quantitative method for describing steric effects. In addition, a laboratory exercise was designed and incorporated into Longwood University's Organic Chemistry Laboratory II course. The implementation of the exercise was evaluated and suggested that students are receptive to new teaching styles.

SYNTHESES AND SOME SPECTRAL PROPERTIES OF NON-LINEAR OPTICAL CHROMOPHORES WITH 1:1 TO 1:3 RATIOS OF ELECTRON-DONATING:ELECTRON-WITHDRAWING GROUPS PER MOLECULE. Godson C. Nwokogu, Dept. of Chem., Hampton University, Hampton, VA 23668. The magnitude of the second order hyperpolarizability constant, for chromophores consisting of an electron-donating group connected to an electron-withdrawing group through a conjugated polyene bridge are usually optimized through structural features such as the match between donor and acceptor groups or the length of the polyene bridge. In this project, the effect of varying the ratio of electron-donating-to-electron withdrawing groups is investigated. Starting from tris-(p-bromophenyl)amine **1**, one, two or three cyclohexenone moieties have substituted the appropriate number of bromines to produce corresponding mono-, bis- or tris-[p-(cyclohexen -1-on-3-yl)phenyl]amines **2**. These cyclohexenone derivatives were successfully condensed with thiobarbituric acid in CCl_4 in high yields to produce the corresponding chromophores **3** with the amino-group donor and one, two or three thiobarbituric acid residues as electron-withdrawing groups per molecule. Preliminary absorption and emission spectra indicate a significant red shift from 1:1 to 1:2 but a minimal red shift from 1:2 to 1:3 chromophores. The substances show amorphopus character and thermal stability well above 300° C.



DEVELOPMENT OF GC-MS AND CHEMOMETRIC METHODS FOR THE ANALYSIS OF ACCELERANTS IN ARSON CASES, Boone M. Prentice, Melissa C. Rhoten, and Sarah E. G. Porter, Dept.of Chem./Physics, Longwood University, Farmville, VA There is an interest in the forensic community in identifying accelerants by their gas chromatography-mass spectrometry (GC-MS) profile. In this work, samples of accelerants were analyzed by GC-MS and compared using chemometric analysis. Four analytical standards (unweathered gasoline, diesel fuel, kerosene, and mineral spirits) were purchased from Restek®, and regular, mid-grade, and premium unleaded gasoline were purchased at the local Valero gas station. GC-MS analysis was performed on a 30m x 0.25 mm x 0.25 μm VF-1ms capillary column using a Varian GC-MS system with the following conditions: split injection (3:1) at 250 °C; temperature programmed from 50 (2.5 min isothermal) to 300 (5.83 min isothermal) at 15°C/min; helium carrier gas at a flow rate of 1 mL/min. The GC-MS chromatograms were assembled into a single data set and compared using principal component analysis. A pattern recognition algorithm was developed based on the variance-covariance matrix of the data set. Replicate analyses of the analytical standards constituted a set of training data to which the purchased gasoline samples could be compared.

STRENGTHENING GLOBAL COOPERATION IN SCIENCE AND SCIENTIFIC RESEARCH, Isai T. Urasa, Department of Chemistry, Hampton University, Hampton, VA 23668. International collaborations in science and scientific research can play a vital role in promoting global economic growth, improving human health, building human capacity, and protecting the environment. To a large extent, such collaborations cannot be sustained in the absence of strong international higher education partnerships that support the exchange of students and scholars. This paper will provide an overview of current practices of international higher education, highlighting the challenges and opportunities that exist for American higher education institutions.

ENDOCRINE DISRUPTORS (EDCs). WHO ARE THEY, WHAT ARE THEY AND WHERE ARE THEY? Roy L. Williams, Professor Emeritus, Dept. of Chemistry and Biochemistry, Old Dominion University, Norfolk, VA 23539-0126. The US public has suddenly become aware of the presence of a wide variety of organic chemicals in many drinking water utilities throughout the country. These chemicals are now known as endocrine disruptors (EDCs) and pharmaceuticals and personal care products (PPCPs). EDCs are known to be estrogen agonists and may affect hormonal activity and sexual development in a wide variety of aquatic life. There presence is alarming due to their potential health effects and the risk of long term exposure is currently a major concern to the drinking water industry and the federal government. To date there are no federal regulations governing these compounds and most conventional drinking water treatment schemes are not effective for the removal of the EDCs and PPCPs. The major source of these EDCs and PPCPs appears to be from inadequately treated waste water effluents that impact certain raw water sources. This paper will provide an overview of the nature and problems associated with this new class of drinking water contaminants.

Computer Science

DESIGN AND SIMULATION OF SMART EMERGENCY SERVICE VEHICLES IN VEHICULAR AD HOC NETWORKS. Syed R. Rizvi[1], Stephan Olariu[1], Mona E. Rizvi[2] & Michele C. Weigle[1], [1]Dept. of Computer Science, Old Dominion University, Norfolk, VA 23529 and [2]Dept. of Computer Science, Norfolk State University, Norfolk, VA 23504. Vehicular Ad Hoc Networks (VANETs) have recently been proposed as one of the promising ad-hoc networking techniques that can be used to provide a safe and enjoyable driving experience. Vehicles on the road form VANETs, whose main purpose is to exchange messages related to traffic safety and other security-related events. VANETs have unique requirements with respect to applications, communication types, self-organization and many other issues. With multi-hop communication, each vehicle can benefit from the locally sensed data of surrounding vehicles or from multi-hop access opportunities. This paper provides the design approach, analysis and simulation results for the recently

proposed novel chaos reducing information dissemination approach for spatio-temporal traffic information related to first responders and evacuation scenarios using VANETs. Our VANET-based design can be used to enhance the effectiveness of existing evacuation plans and to reduce chaos and confusion among victims and first. Due to the prohibitive cost of deploying and implementing such a system in real world, most research in VANET-based systems relies on simulations for evaluation. We use a realistic mobility as well as traffic model. Simulation results show that our approach works efficiently without fully relying on any message relaying infrastructure.

SELF SIMILARITY AND COMPUTER SECURITY. Yen-Hung Hu, Department of Computer Science, Hampton University, Hampton, VA 23668. Self similar nature has been seen in some computer and network activities and several literatures have demonstrates that it could be adopted to enhance the identification and verification of computer and network anomalies. In this paper, we study the mathematic and statistical characteristics of self similarity and survey and investigate the most famous computer and network activities to realize which of them shows self similar nature. To extend our understanding, we assess and examine the existing approaches that include self similarity in their algorithms and analyze performance of them. Meanwhile, we depict a novel framework that integrates several modules, where each of them could be arranged to detect anomalies of a specific computer and network. To evaluate our design, performance study of our framework has been conducted through various systematic computer and network simulations.

A SPARSE LINEAR SOLVER. Stephen V. Providence, Department of Computer Science, Hampton University, Hampton Virginia 23668.This research is centered on the special case of a sparse Cauchy-like matrix by dense vector product computation. Projects of this kind are of importance to researchers in signal processing and computational mathematics. We consider Trummer's highly important problem and the classical problems of polynomial interpolation (p.i.) and evaluation (p.e.) For all problems we substantially improve the known algorithms by devising nontrivial transformations of the associated structured matrices. The transformations reduce p.i. and p.e. to application of FFT, DCT or DST and to solving Trummer's problem in the special case where the solution by Rokhlin's algorithm is highly efficient. Our solution of p.e. and p.i. is in turn extended to efficient solution of Trummer's general problem. The resulting numerically stable algorithm solves all the 3 problems (that is, p.i., p.e. and Trummer's) at the cost $O(n \log n)$, versus the bounds of order $n \log^2 n$ supported by the known numerically unstable algorithms, whereas the bound $O(n \log n)$ was known for Trummer's problem only under a substantial restriction on the input class. The reader is referred to [PSLT93], [PZHY97] and [PACLS98] on some preceding work

on the structured matrix approach to p.e./p.i. and Trummer's problems exploiting Rokhlin's algorithm and the transformations of the problems into each other.

Education

DOES STUDENT PREPARATION FOR LECTURES AFFECT TEST SCORES? Lisa S. Webb, Christopher Newport University, Department of Biology, Chemistry and Environmental Science, 1 University Place, Newport News VA 23606. It is commonly acknowledged among faculty and students that the average college student does not prepare for lectures. This lack of preparedness leads to instructor frustration due to a (real or) perceived suboptimal utilization of class time and student frustration due to the lack of familiarity with the background concepts and vocabulary presented in the lecture. I hypothesize that student learning (as measured by scores on lecture exams) would increase if students would prepare for lectures. In order to test this hypothesis, I gave students written assignments on the learning objectives that would be covered in the course. Students would need to either read the textbook or utilize some other source to obtain the information necessary to complete the assignments, which were collected immediately before the material was covered in class. I collected data from 495 students taking a junior level introductory Cellular Biology course over the last four years. During that time, the course was taught using the same set of learning objectives and in the same organizational format (e.g. two or three lecture exams, several in-class quizzes, a semester exam, a weekly four-hour lab). Data, in the form of pooled exam score averages and variances from the control group ($n = 278$) and the experimental group ($n = 217$) were analyzed using a two-tailed t-test, and were determined to be not significantly different ($p = 0.448422$). This indicates that preparation for lecture does NOT significantly affect test scores.

CONFIGURATION OF A LARGE CLOUD CHAMBER FOR STUDENT RESEARCH AND MUSEUM DEMONSTRATIONS IN PARTICLE PHYSICS AND CHEMISTRY. Nicole K. MacCracken & David B. Hagan, George Mason Univ. and Science Museum of Virginia, Richmond, VA. The cloud chamber at the Science Museum of Virginia is an excellent resource for student research. It allows natural background radiation to become visible in the supersaturated isopropyl alcohol vapor that forms above the chilled liquid alcohol at the base of the observation chamber. The cloud track of each subatomic particle is distinct, allowing for easy identification of the particle. There are three main sources for the natural radiation seen in the cloud chamber: Solar, galactic, and terrestrial. The solar source of radiation comes from the charged cosmic wind, and the terrestrial source is a result of the natural radioactive decay of radon and other molecules found in the earth. The galactic source of natural radiation is resultant of cosmic rays, extremely energetic particles from outside our solar system. These particles undergo extensive decay in our atmosphere, producing protons, neutrons, electrons, positrons, and high

energy muons. All of these particles are visible and available for study in the cloud chamber. Future student research can be enhanced by the addition of an electromagnet to the cloud chamber. Studying low energy particles' effect under the electromagnet force can allow for an individual particle's energy and source to be found algebraically. The possibilities for student research with the cloud chamber are numerous, as topics in chemistry, physics, astronomy, and earth science are just a few that can be explored with the Science Museum of Virginia's cloud chamber.

THE VALUE OF HISTORY IN THE MATHEMATICS CLASSROOM. W. Michael Gentry, Dept. of Mathematics, Mary Baldwin College, Staunton, VA. 24401. Historical problems, defined as questions originating hundreds of years ago, can be understood, appreciated and explored in today's classrooms. The purpose of this paper is to demonstrate that the use of historical problems illustrates the evolution of heuristic processes.

AN EVALUATION OF TEACHER PLANNING FOR A MUSEUM FIELD TRIP: ARE LEARNING OBJECTIVES ALIGNED WITH MUSEUM PROGRAMS? Sarah F. Howell & Eugene G. Maurakis, Curry School of Education, Univ. of Virginia, Science Museum of Virginia, Richmond, VA. With some of the pressures facing today's public schools, the inclusion of out-of-classroom science learning experiences with the traditional science curriculum has been challenged. To better improve museum programming in order to attract more school groups and educational field trips, I examined how well aligned the objectives of the Science Museum of Virginia (SMV) were to the objectives of the teachers using their programs, including SMV's Museum Learning Links. I interviewed 3 teachers to find out what activities they had planned and what objectives and goals they intended the students to meet while at the museum. Similarities and common themes among the teachers were compared to the mission statements and exhibit criteria of the SMV in order to see where there were commonalities and/or mismatched goals. It seemed that the teachers had broader, more "big picture" goals for the students, as opposed to specific content objectives and none of the teachers had heard of the Museum Learning Links program. This leads me to believe that there needs to be more communication between the teachers and museum about the content of the exhibits, in order to connect that content with the students in an appropriate way.

Environmental Science

TRENDS IN OZONE-INDUCED FOLIAR INJURY ACROSS VIRGINIA, 1997-2006. Anita K. Rose, US Forest Service, Forest Inventory and Analysis, Knoxville TN 37919. Ozone (O_3), significant air pollutant affecting vegetation, can occur at

concentrations that cause visible foliar injury on a number of plant species. The USDA Forest Service tracks foliar injury with the goal of determining where negative impacts to forest trees may be occurring across the landscape. O_3 injury was tallied on open areas (biosites), at least 1 acre in size. At each biosite 30 plants of at least 2 indicator species were inspected for ozone injury. A plot-level foliar injury index (biosite index) was derived from the amount and severity of injury recorded at each biosite. Between 1997 and 2006, 20,685 plants across Virginia were evaluated for ozone injury. The highest occurrence of plant injury was in 1997 and 1998. While 1997 had the 2nd highest % of plants with injury, the average biosite index was highest in 1998 and 2000. Biosites with moderate to severe injury occurred in 5 of the 10 years. However, since 2001, injury occurred on < 5% of plants, and the average biosite was <5. In addition, little or no injury was detected in 2004 through 2006. When it did occur, ozone-induced foliar injury was often most prevalent on the Coastal Plain. Except for 2003, these field assessments indicate that between 2002 and 2006 very little ozone foliar injury occurred across the state of Virginia. This was in contrast to the previous 5 years (1997-2001) where between 7 percent and 38 percent of biosites in every year, except for 1999, exhibited moderate to severe ozone injury. Hopefully, this trend of decreasing or very little ozone-induced injury will continue in the future. The continued collection of this type of data will enhance our ability to determine the impacts, if any, of ozone injury occurring across the US.

A PRELIMINARY STUDY OF *ISONYCHIA* MAYFLY (EPHEMEROPTERA: ISONYCHILDAE) NYMPHS AS STANDARD TOXICITY TEST ORGANISMS. B.S. Echols[1], D.S. Cherry[1], R. J. Currie[2], M.K. Chanov[1]& A.S. Carlson[1], [1]Department of Biological Sciences, Virginia Tech, Blacksburg VA 24061 and [2]Toxicology and Environmental Research and Consulting, The Dow Chemical Company, Midland MI 48674. Benthic macroinvertebrates or aquatic insects are widely used in field studies to assess the environmental effects of pollution. Insects belonging to the order Ephemeroptera (mayflies) are well documented as sensitive indicators of water quality; however, these organisms have been rarely used in laboratory bioassays. The purpose of this project was to conduct a series of laboratory toxicity tests with a single mayfly species (*Isonychia spp.*) to assess the feasibility of using this species as a standard bioassay organism. *Isonychia* nymphs were tested in both a coal processing effluent and a reference toxicant (NaCl). No Observed Effect Concentration (NOEC) values were consistently lower for *Isonychia* survivorship compared to the much more sensitive reproductive endpoint for *Ceriodaphnia dubia*. However, *C. dubia* were more sensitive to the NaCl after a seven-day chronic exposure than *Isonychia*. Compared to other standard test organisms endorsed by the USEPA, *Isonychia* are second behind *C. dubia* in sensitivity to NaCl, while NOECs for *Daphnia magna, Pimephales promelas* (fathead minnow) and *Hyalella azteca* (amphipod) are at least two-fold higher. Results of these tests indicate that *Isonychia* may be a suitable test organism for determining effluent toxicity; however more research must be done to support these findings.

MONITORING THE PROGRESS OF STORM WATER MANAGEMENT PONDS OF CENTRAL PARK AND AN OFF-SITE WETLAND MITIGATION PROJECT. K. Oldham, L. Neese, L. Maxfield & M. Bass, Department of Earth and Environmental Sciences, University of Mary Washington, Fredericksburg VA 22401. The Silver Company built the commercial Central Park, in an area with six acres of wetland that required mitigation with two other areas; benches around storm water management ponds that are in Central Park itself and an off-site in Spotsylvania County. The constructed wetland was created adjacent to a natural wetland. In 2002, construction of a housing development began on top of a hill next to the off-site mitigated wetland. Monitoring involved water analysis for dissolved oxygen, temperature, conductivity, pH, nitrates, phosphates, alkalinity, and total hardness in both locations. Within the off-site wetland, a survey of woody stems was done to assess the progress of the site towards a forested wetland. A comprehensive list of woody and herbaceous species was generated showing a slight increase from last year, indicating succession toward a healthy wetland ecosystem. The water analyses results showed no unusual levels of compounds tested were found in either the SMPs or the constructed wetlands and were well within required limits. A density of 565 woody stems per acre was calculated and is well above VDEQ's requirement of 400 woody stems per acre for a forested wetland. Soil coring showed hydric soil throughout the constructed wetland and additionally areas that were originally designated as upland. This wetland mitigation site has exhibited success and will be monitored in the future.

THE ECOTOXICOLOGICAL RECOVERY OF THE BLACK CREEK WATERSHED AFTER REMEDIATION OF ACID MINE DRAINAGE SEEPS. M.K. Chanov II[1], B.S. Echols[1], R. Currie[2], D.S. Cherry[1], C.E. Zipper[3], [1]Department of Biological Sciences, VPI and SU, [2]The Dow Chemical Company, 1803 Building, Midland, MI 48674, and [3]Department of Crop and Soil Environmental Science, VPI and SU. Acid mine drainage (AMD) impacts the coal mining areas throughout the United States. The Black Creek Watershed (Wise County, VA), a subwatershed of the Powell River, has been affected by extensive AMD seeps. The Black Ck subwatershed has undergone extensive remaining for coal with active remediation of the Abandoned Mine land (AML) and AMD seeps as part of the mining activities. New holding ponds were developed to encourage settling of precipitates from some of the seeps that remain. The Black Ck subwatershed has had some of the toxic seeps remediated using and open water wetland system that allows for increased retention time to allow for toxic elements to settle out. However, some of the toxic seeps present in the 1990s are still there today and continue to exert effects on the subwatershed. The conditions in the upper mainstream have improved with measured pH and conductivity. However, lower mainstem sites had considerably higher conductivity values due to the active mining still being conducted in this watershed. Aluminum and iron (Al and Fe) in the water column was relatively high in the unremediated seeps, but were at much lower levels in the mainstream. Al and Fe in the sediments throughout the subwatershed were elevated when compared to un-impacted sites. Laboratory and field tests showed that the unremediated seeps

remain acutely toxic, but that the effects of this acute toxicity are not measured in the mainstream. At the lowest sites in Black Ck, a toxicity issue was discovered with *in situ* Asian clams because clams at these lower sites died and was conformed with laboratory sediment tests with *D. magna*. These parameters indicate that since remediation there has been some increase quality in this subwatershed, however, significant ecotoxicological problems still remain.

CAN SEA-SALT AEROSOLS SERVE AS A SINK FOR GASEOUS MERCURY? Matthew C. Richardson, Brianna M. Strain & Elizabeth G. Malcolm, Department of Earth and Environmental Sciences, Virginia. Wesleyan College, Norfolk VA 23502. Today mercury (Hg) is a pollutant of great concern due to its widespread contamination and neurotoxic effects. An important source of this Hg in aquatic ecosystems is atmospheric deposition. A thorough understanding of the atmospheric chemistry of Hg is vital for predicting the fate of these anthropogenic Hg emissions. This ongoing study investigates whether sea salt aerosol may be an important sink for gaseous mercury by adsorbing either reactive gaseous mercury (RGM) or elemental gaseous mercury (Hg^0). In phase one of this study ambient air in Norfolk, VA was passed over surfaces coated with NaCl. For phase two of this study a laboratory manifold was designed and tested in which NaCl and seawater coated surfaces are exposed to controlled concentrations of an RGM compound, $HgCl_2$. In phase one, 40-70% of RGM and < 0.1% of Hg^0 were absorbed by the NaCl surface. These initial results support the hypothesis that sea-salt aerosols can scavenge RGM, potentially increasing deposition of this form of Hg in coastal environments.

Medical Science

5-HT_3 RECEPTOR AGONISTS AS ANALGESIC ADJUVANTS. Genevieve W. Sirles & Malgorzata Dukat, Department of Medicinal Chemistry, School of Pharmacy, Virginia Commonwealth University, Richmond, VA 23298-0540. *meta*-Chlorophenylguanidine (MD-354) was identified as an analgesia-enhancing agent that seems to act both by a 5-HT_3 and $\alpha_{NON\text{-}2A}$-adrenoceptor mechanism (i.e. MD-354 produces a biphasic response). To further evaluate the role of the underlying 5-HT_3 mechanism, SR 57227A (4-amino-(6-chloro-2-pyridiyl)-1 piperidine), a high affinity, selective 5-HT_3 receptors agonist, with both peripheral and central actions, was examined in the mouse tail-flick, hot-plate and locomotor activity assay. SR 57227A (0.3-10.0 mg/kg) lacked antinociceptive effects in the mouse tail-flick assay when administered either alone or in combination with ED_{50} dose of clonidine. Interestingly, significant antinociception was observed at a high dose of SR 57227A (30.0 mg/kg; $P<0.01$) in the mouse hot-plate assay. The lower doses (0.3-10.0 mg/kg) of SR 57227A neither potentiated nor attenuated the antinociceptive effect of ED_{50} dose of clonidine. SR 57227A had no effect on mouse motor activity. It might be concluded that a 5-HT_3 receptor mechanism is involved in the

antinociceptive/analgesia-potentiation action of both SR 57227A and MD-354. (Supported by: The Jeffress Memorial Trust RG-J-778).

ANTINOCICEPTIVE ACTIONS OF TDIQ – AN ISOBOLOGRAPHIC ANALYSIS. Genevieve W. Sirles, Jessica Worsham, & Malgorzata Dukat, Department of Medicinal Chemistry, School of Pharmacy, Virginia Commonwealth University, Richmond, VA 23298-0540. TDIQ (5,6,7,8-tetrahydro-1,3-dioxolo-[4,5-g]isoquinoline), an agent that binds to all three α_2-adrenoceptors (ARs), was shown to potentiate the analgesic effect of clonidine (an α_2-AR agonist) in the mouse tail-flick assay. The analgesia-potentiation effect appears to be selective because TDIQ had no effect on clonidine's hypolocomotion. In the present investigation mechanistic studies with α_2-AR antagonists: BRL-44408 (α_{2A}), imiloxan ($\alpha_{2B/2C}$), and ARC-239 (α_{2C}), showed that the potentiation effect of clonidine by TDIQ is complex and involves more than one subtype of α_2-AR. All three antagonists blocked the analgesia-potentiation effect of TDIQ. Another purpose of this study was to determine if the nature of the potentiation effect was additive or supra-additive (i.e. synergistic). To evaluate synergism, the experimental ED_{50mix} of TDIQ/clonidine combinations (fixed-ratio) were compared to the theoretical ED_{50add} of a simply additive mixture having the same proportions. The isobolographic analyses, using a 3:1 (ED_{50add} = 1.76 mg/kg; ED_{50mix} = 0.79 mg/kg) and 12:1 (ED_{50add} = 5.72 mg/kg; ED_{50mix} = 1.64 mg/kg) fixed-ratio of TDIQ/clonidine dose, showed that these two combinations behaved synergistically; that is, the combinations had an exaggerated effect compared to the effect produced by the sum of each drug administered alone. (Supported by: The Jeffress Memorial Trust RG-J-778).

BINDING MODE(S) OF ARYLGUANIDINES AT IONOTROPIC h5-HT_{3A} RECEPTORS. Katie E. Ownby, Justin Elenewski & Malgorzata Dukat, Department of Medicinal Chemistry, Virginia Commonwealth University, Richmond VA 23298. Within the last decade we have shown that several arylguanidines and arylbiguanides bind with high affinity at 5-HT_3 receptors. Through mutagenesis studies, amino acids involved in the binding of serotonin and a few 5-HT_3 receptor antagonists have been elucidated. However, the binding modes of arylguanidines have not yet been investigated. To identify possible binding modes of various arylguanidines, molecular modeling was employed. Fifty homology models of the h5-HT_{3A} receptor were constructed using several other ligand-gated ion-channels for alignment of the h5-HT_{3A} receptor sequence to the binding domain of the nicotinic acetylcholine receptor (nAChR). Sybyl and Modeller were used to generate the models based on a template of the crystal structures of the binding domain of the nAChR (PDB 2qc1) and the acetylcholine binding protein (PDB 1i9b). The models were validated by docking a 5-HT_3 receptor agonist, serotonin, and 5-HT_3 receptor antagonist, granisetron, using GOLD or AutoDock programs. The docking results revealed two binding modes; one for agonists and another for antagonists. *meta*-Chlorophenylguanidine (MD-354), a 5-HT_3 receptor partial agonist, was docked and

found to utilize a binding mode similar to serotonin. Conformationally constrained analogs of MD-354 were synthesized and their binding mode was evaluated. (Supported by: The Jeffress Memorial Trust RG-J-778).

IN SEARCH OF QUANTITATIVE TRAIT LOCI: MORPHOMETRIC ANALYSIS OF RECOMBINANT INBRED STRAINS OF MICE. Lisa S. Webb, Christopher Newport University, Department of Biology, Chemistry and Environmental Science, 1 University Place, Newport News VA 23606 & Brynn H. Voy, Biosciences Division, Mammalian Genetics and Genomics Section, Oak Ridge National Laboratory, P.O. Box 2008, Oak Ridge, TN 37831. Recombinant Inbred mouse strain panels enable both genetic association studies and the integration of multi-system, multi-investigator datasets due to their stable genetic architecture. As such, RI strains are a valuable model for the study of complex traits. Our long term goal is to dissect the genetic interactions that control adipose tissue mass due to its relationship with many disease processes, such as Type 2 diabetes. As a starting point, we collected and analyzed morphometric and phenotypic data on 41 strains of BXD (C57BL/6J X DBA/2J) RI mice, a panel selected for its size and its wealth of existing multiscale data for other traits. Fasting plasma glucose levels, body weight, organ (heart, kidney, liver, thymus, spleen) and fat pad weights were measured from adult male and female mice, 3-5 mice per strain. Adiposity index was calculated to reflect overall fatness. Existing genotype data and analytical tools resident within WebQTL were used to screen for regions of the genome containing polymorphisms that co-segregated with each trait. Several genomic regions of interest were identified, particularly for adiposity. Parallel analysis of relevant molecular traits is underway. Genomic regions of interest and potential candidate genes within those regions will be presented. This study was funded in part by the U.S. Department of Energy, Office of Science (FaST Program) and a Dean's Office Grant from Christopher Newport University.

ECSTASY AND THE HEART: INTRACELLULAR AND FUNCTIONAL IMPACT. D. A. Tiangco[1], S. Halcomb[1], F. A. Lattanzio, Jr.[2], S. J. Beebe[2] & B. Y. Hargrave[1], [1]Department of Biological Sciences, Old Dominion University, Norfolk VA 23529 and [2]Department of Physiological Sciences, Eastern Virginia Medical School, Norfolk VA 23501. 3,4-Methylenedioxymethamphetamine (MDMA) is a popular and illicit psychoactive drug. The effects of this compound on the heart have not been fully described. The current study used direct intraventricular transduction to measure acute functional responses to MDMA in the intact rabbit. Confocal microscopy and enzyme-linked immunosorbent assay (ELISA) was used to measure intracellular Ca^{2+} and nuclear factor-kappa B (NF-kB) activation respectively in cultured rat cardiac myocytes (H9c2) exposed to MDMA. In the rabbit, MDMA (2 mg/kg) caused a significant increase in heart rate and a significant decrease in duration of cardiac cycle. Inhibition of nitric oxide synthase by administration of L-NAME, aggravated the functional abnormalities induced by

MDMA. Exposure of H9c2 cells to 1.0 mM MDMA caused increased intracellular Ca^{2+} within 5 minutes. Exposure of H9c2 cells to 1.0 mM MDMA for 6 hours and 2.0 μM MDMA for 12 hours caused increased nuclear localization of NF-kB. Together, the current results suggest that MDMA may be acutely detrimental to heart function. In addition, this drug may be directly cardiotoxic in a temporal and dose-dependent manner through its ability to alter Ca^{2+} homeostasis and activate the NF-kB response.

PHENYLALKYLAMINE BINDING AT 5-HT_2 RECEPTOR SUBTYPES: A 3D-QSAR ANALYSIS. G.K. Jennings & R.A. Glennon, DEPT OF MEDICINAL CHEMISTRY, VIRGINIA COMMONWEALTH UNIVERSITY, RICHMOND, VA 23298. Comparative Molecular Field Analysis (CoMFA) WAS USED To elucidate properties that contribute to the binding affinities of a series of phenylalkylamines at r5-HT_{2A} and h5-HT_{2A} receptors and to generate models capable of predicting affinities of these compounds based on their structure alone. A series of 31 and 25 phenylalkylamines with confirmed agonist properties at r5-HT_{2A} and h5-HT_{2A} receptors, respectively, was used to generate models. Computational energy minimizations were performed on the constrained high-affinity agonist, 1-(4-bromo-2,3,6,7-tetrahydrofuro[2,3-*f*]benzofuran-8-yl)propan-2-amine using SYBYL 7.3. From this structural template the remainder of both series were constructed and minimized in the same way. Semi-emperical methods were then used to generate charges for each molecule. Both series of compounds were aligned using the minimized structure of 1-(4-bromo-2,5-dimethoxyphenyl)propan-2-amine (DOB) as a template. Models generated a predictive $q^2 = 0.696$ and a non cross-validated $R^2 = 0.970$ for the r5-HT_{2A} model and $q^2 = 0.690$ and $R^2 = 0.981$ for the h5-HT_{2A} model. Structural features of this series have been highlighted as points for modification to increase affinities; with ongoing models of 5-HT_{2B} and 5-HT_{2C} subtypes, comparisons could be made in order to exploit features to design selective agents. This is beneficial in that certain of these agents are drugs of abuse and some display toxicity. [Supported in part, by the Lowenthal Endowment]

EFFECT OF ANTICANCER DRUG TAMOXIFEN ON SIGNAL TRANSDUCTION IN HUMAN PLATELETS. Vidhi P. Shah, & Yuliya Dobrydneva, Dept. of Physiological Sciences, Eastern Virginia Medical School, Norfolk VA 23501. Intro: Tamoxifen (TAM) is widely used for the prevention and treatment of breast cancer. However, TAM also increases the incidence of thrombosis. Since excessive stimulation of platelets can lead to thrombosis, we investigated the mechanisms by which TAM promotes platelet activation. Methods: aggregation, lucigenin chemiluminescence, PAC-1 detection using flow cytometry, $[Ca^{2+}]_i$ measurements with SPEX ACRM spectrofluorometer. Results: We confirmed that TAM increases platelet aggregation. TAM causes expression of the PAC-1 antibody ligand, a marker of platelet activation. TAM generates reactive

oxygen species/superoxide (ROS/SO) in human platelets. NADPH oxidase is one of the sources of ROS/SO in platelets exposed to TAM. The NADPH oxidase inhibitor, apocynin, inhibited TAM ability to increase $[Ca^{2+}]_i$ while its analog 3'-Hydroxy-4'-methoxyacetophenone had small inhibitory effect on TAM action. TAM activates PI_3 kinase as the two PI_3 kinase inhibitors wortmanin and LY294002 inhibited TAM-induced $[Ca^{2+}]_i$ elevation. Conclusions: TAM activates platelets and increases platelet aggregation. TAM activates both PI_3 kinase and NADPH oxidase. NADPH oxidase is involved in the production of ROS/SO and increases in $[Ca^{2+}]_i$. However, the pathway that connects PI_3 kinase to NADPH oxidase is still unknown and will be investigated in our future experiments. Acknowledgements: Commonwealth Health Research Board, American Cancer Research and Prevention Foundation, and American Heart Association, National affiliate.

INTERACTION OF THE SIGMA2 RECEPTOR LIGAND PB28 WITH THE HUMAN NUCLEOSOME. C. Abate, J. Elenewski, & R. A. Glennon, Department of Medicinal Chemistry, Virginia Commonwealth University, Richmond VA 23298. Sigma (σ) receptors, classified into σ_1 and σ_2 subtypes, are endoplasmic binding sites involved in neuroprotective and neuroregulative functions, and are overexpressed in many tumor cell lines. Nevertheless, the physiological function and structure of these receptors have yet to be clarified. In an attempt to isolate the σ_2 receptor, we functionalized the σ_2–selective ligand PB28 and coupled it to a stationary phase, through which lysed human neuroblastoma cells were eluted. The purified proteins were analyzed using MALDI-MS and identified as histones (H1, H1.2, H2A.5, H2B, H3.3A). Several homology models of each monomer (H1, H2A, H2B, H3), dimer (H2AB, H34), and octamer (nucleosome) were generated through MODELLER, using the crystal structure of the chicken nucleosome as a template. The resulting population of models was minimized using NAMD, and both enantiomers of PB28 were docked to each of these models via AUTODOCK. Analysis of the docking studies reveals optimal intermolecular interactions between PB28 and the H2AB dimer. In particular, the cationic piperazine moiety in PB28 is observed to interact with a conserved (D/E)XXE motif located on the second helical segments of the H2A and H2B subunits, with strongest interactions seen on the H2B face of the H2AB dimer. Furthermore, the aromatic portion of PB28 preferentially docks in a hydrophobic region between H2A and H2B.

DOCKING AND FUNCTIONAL INTERACTIONS OF AGONISTS AND ANTAGONISTS WITH A h5–HT_6 RECEPTOR MODEL. J. E. Elenewski & R. A. Glennon, Department of Medicinal Chemistry, Virginia Commonwealth University, Richmond VA 23298. Agonist activation of monoamine G–protein coupled receptors is believed to occur through an aromatic motif in TM6 (F6.44, W6.48, F6.51, F6.52) lining the ligand binding pocket opposite the TM3 aspartate (D3.32). Biophysical data indicate that this conformational switch initiates a rigid body rotation of TM6 about a conserved proline kink (P6.50), resulting in a relative

intracellular translocation of TM3 and TM6 and hence a change in the fold of intracellular G–protein binding domains. These data have been augmented through the recent publication of two XRD structures of the human β_2–adrenoceptor as well as the XRD structure of a β_2–adrenoceptor / T4–lysozyme chimera. In order to reevaluate the activation process in light of these structures, and to assess their utility for homology modeling, models of the h5–HT_6 receptor have been constructed (MODELLER) using a photoactivated bovine opsin and the chimeric human β_2–adrenoceptor as templates. Ab initio parameterization of ligands (RHF/DFT/B3LYP/6-31G(d), GAMESS), followed by automated ligand docking (AUTODOCK) and molecular dynamics simulation (NAMD), have been performed in order to elucidate the binding modes of several 5–HT_6 receptor agonists and N1-(benzenesulfonyl)tryptamine antagonists. Differences are noted in the ligand binding region between bovine opsin and β_2–adrenoceptor–based models, as well as in the binding modes of agonists and antagonists, indicating that these structures are not equivalent as templates for homology modeling.

THE VASCULAR RESPONSE TO ALPHA-1 ADRENERGIC STIMULATION DIFFERS IN HIGH AND LOW WEIGHT CHICKENS: IMPLICATIONS FOR THE DEVELOPMENT OF A NON-MAMMALIAN GENDER DIFFERENTIATING MODEL OF THE METABOLIC SYNDROME. Oluyinka Akinbinu[1], Paul B. Siegel[2], Arben Santo[1], Ronald M. Lewis[2], Hongbo Zhang[2], Mark A. Cline[3] & Richard P. Wyeth[1], [1]Edward Via Virginia College of Osteopathic Medicine, Blacksburg, VA 24060, [2]Virginia Polytechnic Institute and State University, Blacksburg, VA 24060, [3]Radford University, Radford, VA 24142. While gender differences in blood pressure are appreciated, how these relate to obesity is not well understood. The current study asks if this chicken model mimics the metabolic syndrome in women compared to men in this regard. Age matched, chickens were used; high weight females (HWF), high weight males (HWM); low weight females (LWF) and low weight males (LWM). α_1 adrenergic vasomotor activity was found with serial phenylephrine addition to isolated aortas, prior to and after g-nitro-L-Arginine-Methyl Ester (L-NAME). Efficacy (T_{max}), developed from prior to after L-NAME was different only in LWF ($p<0.007$). Potency (EC_{50}) changes, prior and following LNAME approached significance in HWF ($p<0.06$). No significant changes in T_{max} or EC_{50} were noted in other groups. A significant difference was noted in EC_{50} between LWF and LWM ($p< 0.03$) prior to L-NAME while HWM and HWF showed a tendency ($p<0.07$) prior to L-NAME and HWF showed a lower EC_{50} compared to LWF ($p<0.007$). Following L-NAME, LWF showed greater T_{max} compared to LWM ($p<0.02$). T_{max} was also different ($p<0.05$) when LWF and HWF were compared. This study suggests this model is suitable for evaluating gender effects on hypertension in the metabolic syndrome.

GENDER SPECIFIC MECHANISMS ASSOCIATED WITH THE HYPERTHERMIA AND HYPERTENSION INDUCED BY 3, 4-METHYLENEDIOXYMETHAMPHETAMINE (MDMA, ECSTASY). Richard P. Wyeth[1], Edward M. Mills[2], Arben Santo[3], Chris Hairr[4] & Jon E. Sprague[5], [1]Departments of Physiology, [1]Anatomy, [3]Pathology, Edward Via Virginia College of Osteopathic Medicine, Blacksburg, VA 24060, [2]Department of Pharmacology, Texas University, Austin, TX 78712, [4]Virginia Polytechnic Institute and State University, Blacksburg, VA 24060 and [5]Raabe College of Pharmacy, Ohio Northern University, Ada, OH 45810. MDMA-induced hyperthermia (HyT) and hypertension may be lethal. No specific treatment for MDMA-induced HyT and/or hypertension exists but women have less incidence of HyT. Gonadectomized female (estrogen) and male (testosterone) rats were treated for 10 days and then given saline or MDMA, core body temperatures taken, rats sacrificed and aortas constricted, *in vitro*, with phenylephrine, with or without g-nitro-L-Arginine-Methyl Ester (L-NAME). Norepinephrine (NE) from venous plasma, and uncoupling protein 3 (UCP3), from the gastrocnemius, were measured. Only males developed HyT with MDMA challenge. No correlation between gender, body mass or surface area and HyT was found. No differences in T_{max} prior to L-NAME were seen in any group. EC_{50} increased only in females treated with MDMA and T_{max} increased following L-NAME only in females treated with MDMA. Both males and females showed a significant increase in plasma NE but males showed greater concentrations than females. UCP3 expression following MDMA was 60% less in female than males.

PKC AND PKA INHIBITORS REVERSE ACUTE TOLERANCE TO LOW AND MODERATE BUT NOT HIGH EFFICACY MU OPIOD AGONISTS Lynn C. Hull, Bichoy H. Gabra, Forrest L. Smith, and William L. Dewey Pharmacology and Toxicology, Virginia Commonwealth University Medical Center, Richmond, VA. The present study was designed to investigate possible differing mechanisms of tolerance to opioids of various efficacies. We, as well as others, have shown that the administration of highly selective inhibitors of protein kinase C (PKC) and A (PKA) completely reversed morphine antinociceptive tolerance in mice. We now have investigated whether these inhibitors reverse tolerance to other opioids of low and high efficacy. An 8-hr model of acute tolerance was used in which the test opioid was administered repeatedly at a dose which yielded maximum antinociception in naïve mice. Animals were then challenged with increasing doses of the test opioid with and without the PKC and PKA inhibitors to construct a dose response curve. The 8-hr tolerance to the low-efficacy μ-agonist meperidine and the moderate-efficacy μ-agonists, morphine and fentanyl was fully reversed by the PKC inhibitors Bisindolylmaleimide I, and Gö6976 as well as the PKA inhibitor PKI 14-22. However tolerance to [D-Ala2, N-Me-Phe4, Gly5-ol]-enkephalin (DAMGO), a highly efficacious μ-opioid agonist, was not reversed by injection of either the PKC inhibitor Gö6976 or the PKA inhibitor PKI 14-22 suggesting that μ-opioid receptor desensitization induced by high-efficacy μ-agonists is independent of PKC or PKA

activation. It can be concluded that the mechanisms underlying μ-opioid receptor desensitization may be determined by the agonist activating the receptor. Supported by DA01647 and DA020836.

Microbiology and Molecular Biology – See Biology

Natural History & Biodiversity

BENEFITS AND DRAWBACKS OF USING MANOVA AND CIRCULAR STATISTICS TO ANALYZE BI-VARIATE DATA. Jason J. Schaffler, Cynthia M. Jones, & Dayanand N. Naik, Center for Quantitative Fisheries Ecology and Dept. Statistics, Old Dominion Univ., Norfolk VA 23508. Traditionally, ecologists have relied on qualitative interpretations of bi-plots to explore food web interactions. Food webs are constructed based on flows of carbon and nitrogen and the resulting fractionation between different trophic levels. Rigorous statistical approaches for testing hypotheses in this field have lagged behind other areas of ecology. Recently, circular statistics has been proposed as a means of quantifying differences in food webs. We feel that the limitations of circular statistics has not been fully stated and there are standard approaches available that should be considered. We compare the use of multivariate analysis of variance (MANOVA) with circular statistics.

QUANTIFYING THE VALUE OF A NURSERY HABITAT USING THE SPOTTED SEATROUT (*CYNOCION NEBULOSUS*) IN AN ESTUARINE SYSTEM. Stacy K. Beharry & Cynthia M. Jones, Center for Quantitative Fisheries Ecology, Old Dominion Univ., Norfolk VA 23508. Nursery habitats such as seagrass beds are important for the health and sustainability of many fisheries. In fact, seagrass beds are considered to be "essential nursery habitats" and as a part of the Sustainable Fisheries Act (SFA) of 1996 it was mandated that these areas be protected. However, no one has developed a method of quantifying the important nursery habitats. To designate an area as an "essential fish habitat" greater survival of juvenile fish to adulthood must be met. In the Chesapeake Bay, seagrass beds are considered to be as nursery habitat, but bed -specific survival of juvenile fish is unknown. To estimate survival we are using fish otoliths, or ear bones, as a natural tag from spotted seatrout (*Cynocion nebulosus*). The seatrout is a model species for this work as individuals maintain a tight relationship with their natal beds. Juveniles obtain an otolith chemical signature unique to their natal bed which can be used to identify the natal beds of adults. From this, it will be possible to develop a ratio estimator for the number of adults produced from the relative abundance of juveniles on each bed. This gives us a method for quantifying seagrass beds as essential habitat based on fish production. This work will have far reaching effects,

as managers can use this research as an ecosystem-based approach to adequately assess the value of individual nursery areas.

A COMPARATIVE TIME BUDGET ANALYSIS OF FOUR EMBALLONURID BAT SPECIES AT LA SELVA BIOLOGICAL STATION IN COSTA RICA. Christina Harview[1] & Mirjam Knörnschild[2] [1]Bryn Mawr College, 101 N. Merion Avenue, Bryn Mawr, PA, 19010; [2] Department of Zoology, Institute for Biology, FAU Erlangen-Nuremberg, 91058 Erlangen, Germany. The goal of this study was to determine if there is a connection between mating system and behavioral complexity in four species of Neotropical bats. Twenty-two key behaviors were documented to describe the dayroost activities of four sympatric Emballonurid bats in Costa Rica. Time budget analyses along with focal animal sampling methods were used to observe eight bat colonies with two to ten individuals each. Data show that although there is no correlation between non-interactive behaviors and mating system, there is a positive correlation between interactive behaviors and mating system. This implies that interactive behaviors have a positive evolutionary link to mating systems. Bats with more complex mating behavior may face a selective pressure for more complex interactive behaviors.

THE 2007 VIRGINIA SOCIETY OF ORNITHOLOGY BREEDING BIRD FORAY: A FOCUS ON VIRGINIA STATE PARKS. Andrew S. Dolby. Dept. of Biological Sciences, Univ. of Mary Washington, Fredericksburg, VA 22401. For its 2007 Breeding Bird Foray, the VSO surveyed the Virginia State Park system. Seventy-eight participants spent roughly 270 hours surveying 30 state parks. Park areas ranged from 250 to 7,691 acres, and observation time per park averaged 10.4 hrs. A total of 158 species were detected, and the most common species overall were Red-eyed Vireo, Common Grackle, Tufted Titmouse, and Northern Cardinal. While the most species rich park was Sky Meadows, with 96 species detected, the average number of species per park was 60.7. Sailor's Creek Battlefield had the fewest species. Direct signs of breeding activity, including sightings of obvious pairs, active nests, and juveniles, were reported for 80 species. Variation in species richness across parks was most likely influenced by factors such as habitat diversity, chance detection of rare and unusual species, and area of intact habitat surrounding park boundaries. Comparison of results with those of previous forays revealed declines in many species, especially insectivorous neotropical migrants. Future forays should revisit the state park system.

DIVERSITY OF HYMENOPTERA IN BURNED AND UNBURNED AREAS AT THE BLACKWATER ECOLOGICAL PRESERVE. Braeden A. Miller & Deborah A. Waller, Dept of Biol, Old Dominion Univ., Norfolk VA 23529. The objective of this research was to examine Hymenoptera from sites subjected to prescribed burns

and from control, unburned sites in a longleaf pine forest in southeastern Virginia. In 2002, insects were collected from Malaise traps set in two burned sites and two control sites. Trap collections were made from March through May and specimens identified to order. The present study identified the Hymenoptera in those samples to the family level. Ichneumonidae and Braconidae, both parasitic wasps, were the most abundant families, followed by Sphecidae, which include predatory and parasitic wasps, and Tenthredinidae, the sawflies. Ichneumonidae and Tenthredinidae were most common in the control sites, while Braconidae was found only in the burned areas. Sphecidae was also more common in burned sites. Also present were Scoliidae and Tiphiidae, both parasitic on beetles, and Vespidae, including the paper wasps, yellowjackets and hornets. This research is continuing with the addition of other trap types and collection of host plants and insects to rear parasitoids. A focus will be determining why some families are more prevalent in either the burned or control habitats.

EFFECTS OF POPULATION DENSITY ON SEED PREDATION OF *AESCHYNOMENE VIRGINICA*, A RARE, TIDAL, WETLAND ANNUAL. Tanima Hoque & Alan B. Griffith, Dept. of Biol. Sciences, Univ. of Mary Washington, Fredericksburg, VA 22401. *Aeschynomene virginica* or sensitive joint-vetch is a federally threatened annual legume that is found in populations from southern New Jersey to central North Carolina. Potentially severe seed loss from herbivory has been observed in *A. virginica* populations, but not measured. We studied the effect of population density on seed predation of *A. virginica* at the Vandell Preserve at Cumberland Marsh Preserve in New Kent County, Virginia. In September 2007, all known populations of *A. virginica* were sampled. We censused all plants in each population and measured the area covered by each population. We counted number of seeds produced and number of seeds eaten on ten randomly selected plants in each population. Seed predation rates were defined as either percent of seeds eaten per plant or average percent of seeds eaten in a population. Number of seed eaten per plant increased as seed production per plant increased. But, there was no significant relationship between percent of seeds eaten per plant and number of seeds per plant or number of plants per population. These results are consistent with other seed predation studies where no density dependent relationship of seed loss was found.

COST-TIME EFFICIENCY OF AGING MENHADEN (*BREVOORTIA TYRANNUS*) SCALES VERSUS OTOLITHS. Billy Culver, Jason J. Schaffler, & Cynthia M. Jones, Center for Quantitative Fisheries Ecology, Old Dominion Univ. Norfolk VA 23508. Menhaden (*Brevoortia tyrannus*) have historically been an important commercial fishery of Chesapeake Bay, requiring intense management of the fishery. However, before fisheries management regulations can be formulated, information regarding menhaden population dynamics in the bay is needed. One important piece of information is the age-length relationship of juvenile menhaden.

Traditionally, aging menhaden has relied on scales; however, otoliths are generally accepted to be more accurate. In our evaluation we compared both methods of aging juvenile menhaden from Chesapeake Bay. To evaluate these two methods we compared the predicted lengths of age one juveniles using back calculated lengths-at-age from otoliths and scales. Using repeated measures analysis of variance we were able to determine that the two methods were not significantly different. Since the time to prepare and age menhaden with scales is considerably less than with otoliths, and the cost of equipment is also reduced, the cost-time benefits suggest that aging menhaden with scales is more efficient and to be preferred.

OPISTHOBRANCH MOLLUSKS FROM THE CHESAPEAKE BAY OF VIRGINIA (MOLLUSCA: GASTROPODA: OPISTHOBRANCHIA). Pamela Bray & Deirdre Gonsalves- Jackson, Dept of Biology, VIRGINIA WESLEYAN COLLEGE, Norfolk, VA 23502. Few studies exist documenting the diversity of opisthobranch mollusks from the Chesapeake Bay of Virginia and to date only 21 species have been recorded. The goals of this ongoing research have been to survey and document the diversity of marine slugs in the Atlantic waters of the Eastern Shore and the Chesapeake Bay. Collection of opisthobranchs was done through dredging and wading at low tide. Specimens were identified to the species level and cultured in the laboratory to determine mode of development. Twenty sites and thirty-six specimens were collected from April – August 2007 and March 2008. Two species in Order Nudibranchia, *Doriopsilla pharpa* and *Doridella obscura*, have been identified. Both species were collected from the Atlantic waters of the Eastern Shore and are new records for this area. *Doriopsilla pharpa* appears to show seasonal variation in abundance with April-July being peak abundant periods and lays eggs in late spring/ early summer. Development for *D. pharpa* was confirmed in the laboratory as direct development with eggs hatching within 12 days as juveniles. This study brings the number of documented species to 19% with one additional species not previously recorded from the Chesapeake Bay.

THE ECOLOGY OF FEAR: COLONIZATION AND OVIPOSITION IN AQUATIC SYSTEMS. L. T. Pletcher, J. R. Vonesh, & J. M. Kraus. Dept. of Biology, VCU, Richmond, Virginia 23284-2012. Amphibians and aquatic invertebrates have complexlife histories that link aquatic and terrestrial food webs. It has beensuggested that amphibian reproduction is an important source of carbon to some aquatic systems. This process of energy flow may be shaped by shifts in habitat selection in response to predators. We hypothesized that predators decrease colonization and oviposition of prey, reducing active inputs. Thus predation risk is expected to shift the relative amounts of active and passive subsidies. We manipulated the presence of fish predators in aquatic mesocosms. Results suggest Hylid treefrog eggs and hydrophilid beetles were less abundant in predator treatments. This difference in oviposition and colonization translated into small reductions in calories and ash free dry mass of active inputs. However, passive

allochthonous inputs were more than double active amounts and variable, therefore relative amounts of active and passive inputs did not differ across the levels of predation risk.

THE MANAOSBIIDAE (OPILIONES, LANIATORES) OF PANAMA. Victor R. Townsend, Jr., Department of Biology, VIRGINIA WESLEYAN COLLEGE, Norfolk, VA 23502. In February 2007, harvestmen (116 specimens, 19 species) were collected over five days in Parque Nacional de General Division Omar Torrijos in El Cope, Cocle Province, Panama. In addition to an assortment of cosmetid and sclerosomatid taxa, 10 individuals representing four species of harvestmen from the family Manaosbiidae were captured. A single adult male of *Barrona williamsi* Goodnight and Goodnight 1942 was identified. This is the first record of this species from outside the canal zone. The other specimens represent previously three undescribed taxa, including new species of *Bugabitia* (3 adult females) and *Barrona* (an adult male and female), and a yet unidentified (new) genus (4 specimens). The addition of these taxa increases the total number of manaosbiid species known for Panama and Costa Rica to seven.

DIVERSITY OF CARRION BEETLES AT THE ZUNI PINE BARRENS. Amy L. Simons, Sarah M. Scott & Deborah A. Waller, Dept of Biol, Old Dominion Univ., Norfolk VA 23529. This study was conducted in a longleaf pine preserve where controlled burning is performed to restore the forest. The research objective was to study the density and diversity of carrion beetles (Family Silphidae) in burned versus non-burned areas over a three-year period. Nine beetle species were expected, including members of the genera *Necrodes*, *Necrophila* and *Oiceoptoma* in the subfamily Silphinae, and the genus *Nicrophorus* in the Nicrophorinae. The Silphinae use large carcasses and the Nicrophorinae use small carrion that they bury to rear their young. Two trap types were used: a plastic bottle trap tied to a tree and a wooden trap on the ground. Both were baited with a 50/50 mix of cat food and mackerel. Two sets of four trapping locations (two burned and two unburned) were alternated weekly (first year) or monthly (second and third years). Initially beetles were brought to the laboratory for identification. Later beetles were released following field identifications. Of the nine species expected in southeastern Virginia, seven were found, but *Nicrophorus carolinus* and *Nicrophorus marginatus* were absent from the Zuni Pine Barrens. More beetles were found in non-burned than in burned trapping locations, perhaps due to increased ground vegetation. Beetles were more abundant in summer than any other season, perhaps due to the peak reproductive activity in summer.

ALLELOPATHIC EFFECTS OF *AILANTHUS ALTISSIMA* ON GERMINATION AND GROWTH OF NATIVE AND INVASIVE PLANTS IN SOUTHWESTERN VIRGINIA. Breanna L. Hargbol & Christine J. Small, Dept. of Biology, RU, Radford VA 24142. Invasive species are detrimental to natural systems, frequently altering the abiotic environment and aggressively displacing native species. Like many problematic invasives, *Ailanthus altissima* (Tree of Heaven) grows rapidly, matures early, and reproduces prolifically, often producing > 20,000 seeds per growing season. *Ailanthus* also has been shown to negatively impact ecosystems through the production of allelopathic compounds (e.g., quasinoids) inhibitory or toxic to other plant species. To determine the effects of *Ailanthus* allelopathy on native communities of southwestern Virginia, we collected replicate soil samples from two forested stands dominated by *Ailanthus* (treatment) and two forested stands lacking *Ailanthus* (control). We compared germination, height, leaf production, and root:shoot ratio of *Daucus carota* (Queen Ann's Lace), *Verbesina occidentalis* (Crown Beard), *Lactua sativa* (Lettuce), and *Dipsacus fullonum* (Teasel) grown in these soils. Plant growth was measured three times weekly for six weeks. *Ailanthus* soil negatively impacted germination and leaf production of *D. carota* ($p < 0.05$) but not height. All growth measures of *V. occidentalis* were negatively affected ($p < 0.01$). *Ailanthus* had no impact on *D. fullonum* ($p > 0.30$), a non-native invasive plant. Our results suggest that native plant species may be more severely impacted by allelopathic affects of invasives like *Ailanthus.*

DIVERSITY OF CARRION FLIES AT THE ZUNI PINE BARRENS. Sarah M. Scott, Amy L. Simons & Deborah A. Waller, Dept of Biol, Old Dominion Univ., Norfolk VA 23529. Carrion flies are holometabolous insects whose life cycle is predictable and often associated with certain stages of decomposition. They are important nutrient recyclers in the ecosystem as well as invaluable for the determination of post mortem interval in the field of forensic science. The Zuni Pine Barrens is a tract of land that is primarily composed of *Pinus palustris*, longleaf pine, and burned regularly to promote growth and seed germination. This study focused on Calliphoridae and Sarcophagidae in the burned and unburned habitats. Two hypotheses were tested: 1) carrion fly abundance will differ in burned versus unburned habitats, and 2) some species will be more abundant in the warmer summer months as opposed to the cooler winter months. Little is known of the fly fauna of southeastern Virginia and previous research has not focused on the effects of prescribed burns on fly distributions. Two different trap types were used, including one that collected larvae and another that collected adults. Eight trapping locations were divided into two sets, with each set containing two burned and two unburned areas. Collections were made over a three-year period, and larvae were reared to maturity in the laboratory. Preliminary results suggest that the Sarcophagidae far outnumbered the Calliphoridae. Both families were collected in burned and unburned areas. Distributions and seasonal occurrence of different species will be determined following completion of specimen identifications.

SHEEPSHEAD, *ARCHOSARGUS PROBATOCEPHALUS*, LENGTH-WEIGHT, AGE, AND GROWTH: A COMPARISON BETWEEN AREAS. Joseph C. Ballenger, Hongsheng Liao, Billy Culver, & Cynthia M. Jones, Center for Quantitative Fisheries Ecology, Old Dominion Univ., Norfolk, VA 23508. Sheepshead are an estuarine/marine member of the porgy family that have long supported large recreational fisheries along the southeastern coast of the United States, with a recently expanding recreational fishery in Virginia waters of the Chesapeake Bay. Due to this expansion into Bay waters, Virginia fisheries managers need to develop a management plan for this species and determine if Chesapeake Bay sheepshead constituted a separate population from sheepshead found further south. However, before any management plan or determination on population structure can be developed, a comprehensive understanding of the age structure and growth rates of fish in the population is needed. To characterize the age and growth of sheepshead in the Chesapeake Bay, we collected fish captured via Bay fisheries and obtained their lengths, weights and ages. Sheepshead ranged in age from 0 to 34 years old, with the oldest fish being 11 years older than the oldest sheepshead previously reported. A Kimura's likelihood ratio test indicated that there is no dimorphic growth differences between sexes with regards to length-at-age or the length-weight regression. Results of the von Bertalanffy length-at-age analysis, weight-at-age analysis, and length-weight regressions suggest that Chesapeake Bay sheepshead are attaining larger sizes than sheepshead found elsewhere along the coast of the United States. This is strongly suggestive that the Chesapeake Bay sheepshead population constitutes a separate population, as large differences in vital rates are often indicative of this.

CORRELATION OF EASTERN WILD TURKEY POULT:HEN RATIOS WITH POPULATION INDICES TO DETECT REPRODUCTIVE DENSITY DEPENDENCE. Jay D. McGhee[1] & Jim Berkson[2], [1]University of Mary Washington, Department of Biological Sciences, Fredericksburg, VA 22401, [2]National Marine Fisheries Service RTR Unit at Virginia Tech, 100 Cheatham Hall, Blacksburg, VA 24061. Knowledge of how density affects population growth is important for the harvest management of wild turkey (*Meleagris gallopavo*). Unfortunately, available time-series are often too short for statistical detection of density dependence. The correlation between wild turkey recruitment and population size was assessed using data from 7 state wildlife agencies, circumventing the problem of short time-series by using multiple datasets. Correlation coefficients were calculated between surveyed poult:hen ratios and harvest-based population indices for 29 geographic or harvest management regions. Correlation coefficients for the 29 regions ranged from -0.82 to 0.70. A Q-test for homogeneity indicated that correlation coefficients were similar enough to warrant averaging [Q=25.45, df = 28, P = 0.603]. The weighted average correlation coefficient (± standard error) was = -0.30 ± 0.17. Population size accounted for little of the variation associated with production (r^2 = 0.09). Graphical analysis indicated that a negative correlation between poult:hen ratios and population size

tended to occur when the range of population sizes was large. Density dependence appears to have little effect on production. Density-independent models should have better success modeling wild turkey production, while stronger density-dependent effects may have stronger influence on survival or immigration at low population sizes.

NECTAR CONSUMPTION BY SPIDERS – A CRACK IN THE GENERALIST PREDATOR PARADIGM. M. A. Milne & D. A. Waller, Department of Biology, ODU, Norfolk, VA 23508. Representatives of three families of spiders (*Linyphiidae, Lycosidae, and Agelenidae*) and one family of harvestman (*Leiobunum*) were assessed in the laboratory for their affinity to consume several types of sugary solutions. Tested sugary solutions included honey, 10% sucrose solution, 5% sucrose solution, 0.5% sucrose solution, extrafloral nectar (*Prosopis glandulosa*), and floral nectar (*Nematanthus gregarius*). All arachnids were exposed to honey, members of *Linyphiidae* and *Lycosidae* were also exposed to 10% sucrose solution, and nectar was only exposed to *Linyphiidae*. Arachnids were simultaneously subjected to water and the specified solution within a large arena and the time that each subject spent consuming the solution was recorded. All subjects drank honey when offered and there was no significant difference between subjects in their time spent drinking honey ($p = 0.434$). The *Linyphiidae* and *Lycosidae* representative both drank 10% sucrose for a longer period of time than the honey ($p < 0.001$), suggesting that the concentration of sucrose may be correlated with the amount consumed. The *Linyphiidae* representative also drank the extrafloral and floral nectar offered.

USING TAGS TO SAMPLE LARGE VALUABLE FISH. N. Prista[1], J. L. Costa[1], M. J. Costa[1] & C. M. Jones[2], [1]Centro de Oceanografia, Faculdade de Ciências da Universidade de Lisboa, Campo Grande, 1749-016 Lisboa, Portugal and [2]Center for Quantitative Fisheries Ecology, Old Dominium University, Norfolk, VA 23508. Fishery-dependent surveys are the main source of biological information for large valuable fish species (LVFS). However, even market sampling surveys can be made difficult by size grading practices, the need to minimize market place interference, the need to preserve specimen's appearance and budget constrains in fish acquisition. In the case of LVFS these situations frequently lead to adoption of suboptimal sampling designs. We developed a new fishery-dependent sampling methodology – termed "commercial mark-recapture" (CMR) - that allows the collection of representative numbers of biological samples (e.g. otoliths) from fisheries landings with minimal cost and reduced sampling site interference while retaining spatial, temporal, size and fishing gear discrimination. The methodology is based on the measuring and tagging of landed individuals for latter recapture of their tags and samples within the commercial circuit. A first application of CMR was performed in Portugal during 2004-2006 in the study of *Argyrosomus regius*, a large valuable sciaenid (over 20lb and 200 USD per fish). A 75% recapture rate was

achieved (279 fish samples, >4 tons of fish, >$60000 in value), at negligible costs. A binomial distribution was used to model this CMR application and can be used to obtain unbiased biological samples from fisheries landings of other LVFS worldwide, including some from Virginia's waters. This study was funded by FCT (grant ref: BD/12550/2003) and DGPA (project Mare ref: FEDER-22-05-01-FDR-00036).

ECOLOGICAL AND VEGETATION RESPONSES FROM TWO DAM REMOVALS IN A TIDAL WETLAND SYSTEM. Damon Lowery & Alan B. Griffith. Dept. of Biol. Sciences, Univ. of Mary Washington, Fredericksburg, VA, 22401. As dam removals have increased in frequency due to dam deterioration and interest in ecosystem restoration, there is a growing need to determine the ecological effects of dam removal. Few studies have been conducted on dam removals and pre-dam removal data is particularly limited. Our interdisciplinary study aims to measure impacts of dam removal on stream physical characteristics, vegetation, aquatic invertebrates, and fish along Holts Creek, a tributary to the Pamunkey River in New Kent County, VA. This research reports pre-dam removal plant distribution and abundances. To assess distribution and abundance of vegetation, ten transects were constructed along the entire drainage between the two dams. The presence of tree, sapling, vine, and herbaceous species were systematically sampled at each transect. Among all transects there were 18 tree species, 23 sapling species, 5 vine species, and 71 herbaceous species. Out of the 71 herbaceous species, the most abundant was *Murdannia keisak*, which is an invasive species. *M. keisak* was present at 6 of the 8 transects sampled, and had an average percent cover of 20%. Several other invasive herbaceous species were also present in high abundances. High relative abundance of *M. keisak* and other invasive species pose a potential problem when dam removal occurs, due to their ability to effectively disperse and quickly colonize newly barren sediments. As dam removal proceeds, it will be essential to monitor the establishment of these species and to determine their effects on other plant species.

CLASSIFICATION OF THE ECOLOGICAL COMMUNITIES OF THE SELU CONSERVANCY IN SOUTHWESTERN VIRGINIA. M.T. Baisey, C.J. Small, & K.A. Francl, Dept. of Biology, RU, Radford VA 24142. The classification of natural communities provides valuable information to better manage conservation efforts. Because plants are especially reliable indicators of biological and ecological conditions, vegetation typically is used to define communities. Selu Conservancy, located in Montgomery County, southwest Virginia, protects ~154 ha of diverse natural communities in Virginia's Ridge and Valley Province. Our research focused on the classification of ecological communities at Selu, supporting efforts by the Virginia Natural Heritage Program to document and protect state natural areas. In 2007, 99 – 100 m^2 sample plots were established throughout the Conservancy to characterize vegetation composition, structure, and associated habitat features

(topography, soil moisture and fertility, canopy cover, etc.). Twelve ecological communities were identified based on ordination and cluster analyses, including two of state significance: Low-Elevation Boulderfield Forests and Basic Mesic Forests. As an extension of this work, our classification is being used to investigate the distribution of small mammals and impacts of invasive species across natural habitats of Selu. These data provide additional information to the already extensive database of Virginia's natural communities. This information will be used to help develop effective conservation programs by allowing focus on management at an ecosystem level rather than on individual species.

RESOURCE PARTITIONING BY SUBTERRANEAN TERMITES IN SOUTHEASTERN VIRGINIA. Kinner M. Patel & Deborah A. Waller, Dept of Biol, Old Dominion Univ., Norfolk VA 23529. The objective of this research was to determine how three very similar subterranean termite species, *Reticulitermes flavipes*, *R. hageni* and *R. virginicus* (Family Rhinotermitidae) coexist in southeastern Virginia. These sympatric species nest underground and feed on surface and buried logs. We established bait grids at three sites at the Blackwater Ecological Preserve in Isle of Wight County. Site I was a mesic pine forest, Site II was a dry pine forest, and Site III was a mesic hardwood forest. Grids were 80 x 80m with 25 cardboard bait traps spaced every 20m. We also measured diameter of logs along 100m transects in each site and identified any termites in the wood. All three species were found in either baits or logs at both Sites I and II. No termites were collected from Site III. Site I had more *R. virginicus*, Site II more *R. hageni*, but *R. flavipes* was present equally at both sites. Logs with *R. flavipes* tended to be smaller in diameter than those with the other species. These results support previous work suggesting that habitat moisture and log size might influence *Reticulitermes* species distributions and foraging patterns.

SURVEY OF SPOTTED SALAMANDERS (*AMBYSTOMA MACULATUM*) IN VERNAL POOLS AT THE WALTER AND INGER RICE CENTER FOR ENVIRONMENTAL LIFE SCIENCES. L. T. Pletcher[1], C. Viverette[2], A. B. Wright[1], J. L. Ware[3], R. Dyer[1], S. Crouch[1], J. D. Kleopfer[4], & R. Knapp[1]. [1]Dept. of Biology, VCU, Richmond, Virginia 23284-2012. [2]Center for Environmental Studies, VCU, Richmond, Virginia 23284-3050. [3]Dept. of Pathology, VCU School of Medicine, Richmond, Virginia 23298 and [4]Virginia Dept. of Game and Inland Fisheries, Charles City, Virginia 23030. Surveys of spotted salamanders (*Ambystoma macualtum*) in vernal pools were undertaken in winter of 2006 and 2007 at the VCU Walter and Inger Rice Center for Environmental Life Sciences. Spotted salamanders occur in Virginia's Coastal Plain, and in Charles City County. Little is known about the population characteristics of these salamanders and the vernal pool community in which they breed. A long-term population monitoring program was begun in eight small vernal pools to understand this breeding habitat, document the timing of the breeding migration, and determine the health status and

population size of spotted salamanders. To date, hundreds of salamanders have been weighed and measured, examined for abnormalities, and photographed. Disease has been documented within the population.

POSTEMBRYONIC DEVELOPMENT IN NEOTROPICAL HARVESTMEN FROM TRINIDAD, W.I. (OPILIONES, LANIATORES, CRANAIDAE). Nouman J. Rana[1], Daniel N. Proud[2], Philip Rock[1], & Victor R. Townsend, Jr.[1], [1]Department of Biology, Virginia Wesleyan College, Norfolk, VA 23502 and [2]Department of Biology, University of Louisiana at Lafayette, Lafayette, LA 70504-2451. In this study, we described postembryonic development in the Cranaidae on the basis of the examination of individuals representing two species, *Phareicranaus calcariferus* and *Santinezia serratotibialis*. Individuals (adults, nymphs and larvae) were collected over the course of three years (2005-2007) on the Caribbean island of Trinidad. The life history of both species features six nymphal stages. Pigmentation and body shape changed dramatically during development. Growth rates for nymphs were similar for both species. In *S. serratotibialis*, the greatest percent increase in leg size occurred from larval phase to 1st nymph. Other ontogenetic changes that were observed included development in the size and complexity of the first cheliceral segment, ocularium, pedipalp, opisthosoma, distitarsus, and leg IV. Postembryonic development in cranaid harvestmen follows a pattern similar to that reported for other species in the Laniatores.

Psychology

TIME PERSPECTIVE AND RISKY BEHAVIOR: MODERATING EFFECTS OF RELIGIOSITY. M. R. Pearson & J. M. Henson. Old Dominion Univ., Norfolk VA. Time perspective and religiosity have yet to be considered together as antecedents to risky behaviors. The present study examined whether religiosity moderates the relationship between five dimensions of time perspective (Present-Hedonism, Present-Fatalism, Future, Past-Negative, Past-Positive) and risky behavior. It was predicted that Present-Hedonism and Present-Fatalism would display a buffering interaction with religiosity, and that Future time perspective would display an antagonistic interaction with religiosity. Survey data were collected from 493 college students. As predicted, a buffering interaction was found between Present-Hedonism and religiosity for two different alcohol outcome measures, indicating that religiosity acted as a protective factor that buffered against the risk associated with Present-Hedonism. However, there was no support for the other predicted interactions. An unexpected synergistic interaction was found between Past-Negative and religiosity in regards to the risky sex outcome variable. Closer analysis reveals that Past-Negative was negatively associated with risky sex, but only for individuals high in religiosity. In sum, there is some evidence that religiosity moderates the relationship between Present-Hedonism and risky alcohol use, and there is preliminary evidence that religiosity moderates the relationship between

Past-Negative and risky sex. Both Present-Hedonism and religiosity need to be considered when one is interested in either.

DISCRIMINATIVE STIMULUS PROPERTIES OF THE GLUTAMATE AGONIST N-METHYL D-ASPARTATE IN C57BL/6 MICE. Sarah A. Vunck[1], Jason M. Wiebelhaus[1], Jørn Arnt[2] & Joseph H. Porter[1]. [1]Department of Psychology, Virginia Commonwealth University, Richmond, VA USA,[2]Lundbeck Research Denmark, Copenhagen-Valby, Denmark. The glutamate hypothesis of schizophrenia postulates that there is a hypo-functionality of the N-methyl D-Aspartate (NMDA) receptor subtype in the psychopathology of schizophrenia. The atypical antipsychotic clozapine (CLZ) has been shown to increase the outflow of glutamate in the prefrontal cortex of rats and enhance NMDA currents. Given this interaction between CLZ and glutamate, it is of interest to evaluate whether the discriminative stimulus properties of CLZ and NMDA are similar to one another. In the current study, two groups of C57BL/6 mice were trained in a two-lever drug discrimination task. One group was trained to discriminate 2.5mg/kg CLZ from vehicle and a second group was trained to discriminate 30 mg/kg NMDA from vehicle. Generalization curves were generated for both groups after training criteria were met, yielding an ED_{50} = 0.92 mg/kg (95% C.I. = 0.66-1.29 mg/kg) for CLZ and an ED_{50} = 10.80 mg/kg (95% C.I. = 7.69-15.16 mg/kg) for NMDA. Cross-generalization testing revealed that NMDA (3, 10, 30, and 56 mg/kg doses were tested) failed to generalize in the CLZ-trained mice. A maximum % drug lever responding (%DLR) of 25.1% occurred at the 56 mg/kg dose, which also produced significant rate suppression. In the NMDA-trained group, CLZ (0.15625, 0.3125, 0.625, 1.25, 1.77, 2.5, and 5.0 mg/kg doses were tested) produced a maximum of 58.8% DLR at the 0.625 mg/kg CLZ dose with rate suppression occurring at the 5.0 mg/kg dose.

REVIEWING THE REVIEWERS: A SECOND LOOK AT BOND & SMITH'S (1996) META-ANALYSIS OF ASCH-TYPE LINE JUDGMENT STUDIES. R.E. Frank, Virginia Wesleyan College, VA 23502 & J.P. O'Brien, Tidewater Community College, VA 23453. Bond and Smith's 1996 cross-cultural meta-analysis of 133 conformity studies using Asch's (1952b, 1956) line judgment task is widely cited both for its findings (more conformity in collectivist than in individualistic cultures; a decline in conformity in the U.S. since the 1950's) and its methodology. Included in this paper, is an Appendix "A" that provides readers with classifications for a subset of the moderator variables included in the meta-analysis, calculations for % errors and % errors controls, and effect size (*d*) values. As part of a larger research effort, 58 of the studies included in Appendix A were independently reviewed. This review revealed 78 discrepancies (52 unambiguous errors and 26 judgment call disagreements) between our reading of the primary sources and Bond and Smith's classifications in Appendix A. The most significant unambiguous error is the reporting of Asch's 1956 % errors controls as 0.5 rather

than as 0.7, a difficulty that affects 34 of the 58 studies in our sample as well as all the studies in the overall sample of 133 studies which used Asch 56 stimuli but which did not report independent control groups. Judgment call disagreements are notable because Bond and Smith saw their task as one of data extraction, not as one of judgment. How these discrepancies escaped notice by the editors/reviewers at *Psychological Bulletin* as well as by the wide audience of scholars who have cited the article in the past decade deserves further study. The immediate lesson learned is that if science is to be more than a collective illusion, each of us must take responsibility for verifying the truth of its claims.

Statistics

A COMPARISON OF DIFFERENT METHODS FOR PREDICTIONG CANCER MORTALITY COUNTS AT THE STATE LEVEL. Corinne Wilson, Department of Mathematics and Statistics, Old Dominion University, Norfolk, VA 23529. Cancer affects everyone. It is the main cause in one out of every four deaths in the United States. The American Cancer Society has used several methods of forecasting to estimate the future cancer burden and researchers are continually working to develop new methods with improved performance. There have been studies comparing different models for predicting the US cancer mortality counts. In this study we explore and compare several different models for cancer mortality count predictions at the state level, especially for the state of Virginia. Different cancers are used in the study and in some cases the models give rather peculiar predictions.

STUDYING THE EFFECTS OF CORRELATION ON PROTEIN SELECTION IN HIGH DIMENSIONAL PROTEOMIC DATA. Savita Venkataramani & Dayanand N. Naik, Department of Mathematics and Statistics, Old Dominion University, Norfolk, VA 23529. Mass-spectrometry based protein profiling is a method to analyze protein expressions of biological samples. One of the main problems of interest here is the selection of critical proteins from a list of thousands of possibly expressed proteins. Typically this selection is done by performing thousands of t-tests or ANOVA F tests (one corresponding to each protein) and ordering them according to the test statistics or the p-values. However, the selection may be affected by the correlation that exists between the test statistics. In a recent paper, Efron (2007, Journal of American Statistical Association, 102, 93-103) provided methods for assessing the effect of correlation in large-scale testing problems. Using two popular microarray data sets, namely, breast cancer and HIV, he illustrated the effect of correlation on the false discovery rate (FDR). Although FDR procedure does not require independence of the tests, existence of correlation grossly under or overestimates the number of critical genes. Efron discusses the use of his empirical null distribution to alleviate this problem. In this note we briefly review Efron's method and apply the similar techniques to proteomics data. In particular we work

with Duke University's lung cancer samples. We show that even in spectrometry proteomics data and for relatively smaller number of simultaneous hypothesis testing, the correlation can affect the FDR values and the number of proteins declared as critical.

AN INTERACTIVE TOOL TO DEMONSTRATE ASSOCIATIONS BETWEEN EDUCATIONAL ATTAINMENT AND ALL-CAUSE MORTALITY. Tina D Cunningham & Robert E Johnson, Department of Biostatistics, Virginia Commonwealth University, Richmond VA 23298-0032. This simple tool was developed to provide the public and policymakers a general picture on the association between educational attainment and mortality in all 50 states and 524 counties in the US. Numerator data (2004 deaths) was downloaded from the National Bureau of Economic Research (NBER) website. Denominator data (2004 population) was downloaded from the American Community Survey (ACS). The number of averted deaths was computed as a function of higher education proportion. Missing information on educational attainment was imputed based on the surrounding states. Population counts for 280 counties were extrapolated from 2006 ACS data. The final result was a website with an interactive tool that enables users to input data and receive personalized output with interactive features.

CONTROL CHARTS WITH MISSING OBSERVATIONS. Sara R. Wilson & Marion R. Reynolds, Jr., Department of Statistics, Virginia Polytechnic Institute and State University, Blacksburg, VA 24060. Traditional control charts for process monitoring are based on taking samples from the process at regular time intervals. However, in practice it is possible for observations, and even entire samples, to be missing. Three methods are investigated for adjusting the weights in the control statistic of the Exponentially Weighted Moving Average (EWMA) control chart to account for missing observations. The case in which individual observations are taken at each sampling point as well as the case in which the sample size is greater than one are examined. Markov chain and integral equation methods are developed to evaluate and compare the statistical properties of these charts. The multivariate case in which information on some of the variables is known while information on the other variables is missing is also considered using Multivariate EWMA (MEWMA) charts.

PROFILE MONITORING ANALYSIS USING SEMIPARAMETRIC AND NONPARAMETRIC METHODS. Abdel-Salam G. Abdel-Salam & Jeffrey B. Birch, Virginia Polytechnic Institute and State University, Blacksburg, VA. Profile monitoring is a relatively new technique in quality control best used where the process data follow a profile (or curve) at each time period. The majority of previous studies in profile monitoring focused on the parametric modeling of either

linear or nonlinear profiles, with both fixed and random-effects, under the assumption of correct model specification. Our work considers those cases where the parametric model for the family of profiles is unknown or, at least uncertain. Consequently, we consider monitoring profiles via two methods, a nonparametric method and a semiparametric procedure that combines both parametric and nonparametric profile fits, a procedure we refer to as model robust profile monitoring (MRPM). We speculate that both methods will be robust to the common problem of model misspecification. Also, we incorporate a mixed model approach to both the parametric and nonparametric model fits. As a consequence, it is speculated that both the nonparametric method and the MRPM method will result in charts with good abilities to detect changes in Phase I data and have simple to calculate control limits. The new methods should provide greater flexibility and efficiency over current parametric methods used in profile monitoring that rely on correct model specification, an unrealistic situation in many practical problems in industrial applications.

ON THE APPLICATIONS OF STATISTICS IN FINANCIAL SERVICES. Seemit Sheth, Capital One Financial Corporation, Richmond, VA. Modern day decision making in financial services is getting sophisticated, and they employ large number of statisticians to make information based decisions that require the use of wide spectrum of statistical theories. In this paper, we look at two such broad areas of statistics - 1. Predictive Modeling, and 2. Design of Experiments, and give a flavor of how multi-million dollar decisions are made using the underlying statistical theories.

STABLE FRAILTY MODELS IN CONTINUOUS BIVARIATE LIFETIME DISTRIBUTIONS. Norou Diawara, Department Mathematics and Statistics, Old Dominion University, VA. This talk describes the estimation technique of the positive stable frailty model that contains a measure of dependence for a continuous bivariate lifetime distributions linearly related. The expression for the likelihood function is given under the modified Cox proportional hazard assumption, allowing inference for arbitrary data. Bayesian procedure is used to accommodate censoring or missing data information.

CLUSTER RANDOMIZED TRIALS IN PRIMARY CARE: SIGNIFICANCE TESTING AND SAMPLE SIZE. Robert E. Johnson, Dept. of Biostatistics, Virginia Commonwealth University, Richmond VA 23298-0032. The randomized control trial is the prominent methodological tool used to establish evidence in medical research. In primary care research interventions are commonly implemented at the practice or physician level. This requires all or a sample of patients within a practice or belonging to a physician's patient panel to be randomized to intervention or

control group. Such clusters must be accounted for in the statistical analysis and determination of sample size. The variance of means or percentages has one component due to variation between the clusters (variation between practices or physicians) and another due to variation within clusters (variation among patients). Common methods of analysis for cross sectional or pre-post designs must be modified to account for these sources of variation. Sample size software is readily available for single group clustered data but is less common for controlled trials and pre-post trials. In this workshop we will illustrate the concepts of variance components and design effects related to cluster randomized trials. Common testing methodologies will be presented. Techniques for determining sample size are included.

Biomedical and General Engineering

SYSTEM MODELING OF MOBILE ROBOTS TEAM BEHAVIOR. Gail V. Megeath, R_Res Lab, Leesburg, VA, 20176. A successful deployment of any kind of systems needs an advanced modeling and simulation. The purpose of the modeling process is evaluation of functional capabilities of systems and performing optimization before their physical realization. The preliminary complex system modeling and optimization considers problems of analysis of operations that the system has to perform and their functional systematization and decomposition aiming to define general system and sub-system functions and goals. The paper considers problems of modeling of team behavior of mobile robots. The robots react when an object is sensed within an observed area. The aim of the robot team is to localize and surround the object while it moves chaotically. A Petri net model based on input, intermediate and output variables is constructed. The number of the variables and their internal organization varies depending on the team configurations around the object. A network system model for modeling and simulation of the team behavior is proposed. The system model realizes parallel computational processes. The number of the processes depends on the assigned team strategy. The functioning of the model is visualized through appropriate graphics.

POSSIBILITIES FOR A PRESSURE IMAGING AND PROCESSING APPROACH TO THE RECOGNITION OF PRESSURE ULCER FORMATION. Patrick C. Headley, Department of Biomedical Engineering, Virginia Commonwealth University, Richmond VA 23284. This work is part of an ongoing study examining the effect of head of bed elevation on skin integrity in the critically ill. Pressure ulcers are an urgent problem among persons with impaired motion, especially critically ill patients. The primary factors contributing to the development of pressure ulcers are pressure and shearing. The larger study utilizes a pressure mapping system consisting of an array of capacitance-based pressure sensors (XSENSOR Technology Corp., Calgary, Canada) to record whole-body

interface pressures between critically-ill patients and their support surfaces. This system is designed primarily for the visualization of pressure; analytical methods were developed using MATLAB (The MathWorks, Natick, MA) to enhance the capabilities of the pressure imaging system concerning the detection of trends possibly leading to pressure ulcer development. These methods enable the user to track the maximum interface pressures and pressure gradients measured on user-defined regions of the body across space and time. These methods, coupled with patient pressure ulcer development data from the ongoing study, hold the possibility to develop a methodology for the real-time clinical recognition of pressure ulcer formation.

A QUIET VEHICLE AVOIDANCE SYSTEM FOR BLIND AND DEAF-BLIND PEDESTRIANS. Justin Owen, Department of Biomedical Engineering, Virginia Commonwealth University, Richmond VA 23284. Modern cars, particularly hybrids at low speeds, are becoming quieter and quieter, posing a great threat to visually impaired pedestrians, who solely use sound to determine the safety of crossing a street. To address this problem, we propose a dualistic solution of both quiet cars adapting to visually impaired pedestrians and vice versa. The first aspect of our solution is for quiet cars to emit sounds sounding like the familiar combustion engine cars for pedestrians to judge their presence. The second aspect is for quiet cars to alert pedestrians of their presence via a Bluetooth connection to the pedestrians' cell phones, with the cell phones providing a vibratory signal to indicate the cars' presence. The redundant nature of our dual solution increases the safety to pedestrians. The system implementation which we propose will help these individuals maintain their independence and mobility while not subjecting them to additional costs.

TOWARDS ENTERPRISE WIDE COST MODELING: CHALLENGES AND SULUTIONS. Yousuf S. Mohammed & Dr. HanP. Bao, Old Dominion University, Norfolk VA 23529. This abstract summarizes the challenges and solutions in coming up with a unified cost estimation model or in other words Enterprise wise cost modeling. Traditionally cost estimation methods and software have concentrated on obtaining the cost estimate for elemental parts and then adding the cost of all such parts that form the system. The problem with this is that the cost of systems engineering effort is not accounted for. Also factors such as uncertainty, maintainability, supply-chain, and socio-economic situation should be taken into account to effectively estimate cost of a system. A cost estimation hierarchy is set up as follows: Objective, Assembly, Product, System, and Program. The research goes beyond just cost of a system. The product domain is expanded from a simple object to a program which is several systems working in conjunction. The cost model caters to the needs of cost estimation at every stage. In the early stages at object level it suggests the user with applicable processes given the material and production quantity. Parametric cost estimation forms the backbone of this cost

model. Attributes such as materials, fabrication, processes, etc. are ontology based. This enables a generic category to branch into more and more specialized categories with each step. This is very useful since in the preliminary stages of cost estimation not much information is available as to what exact material or process is used. In such a case data pertaining to a more generalized material or process can be used. The ontology scheme is carried on to systems level also. Ontology at a systems level classifies common products into categories according to their functionality. This helps put together a system efficiently on paper; locate a product with a certain generic functionality and pull all necessary data to estimate cost. For storing and retrieving data XML is used. In order to deal with stochastic nature of the data collected fuzzy regression, stochastic regression, and Monte Carlo simulation are used. These tools are programmed using Matlab.

BEST STUDENT PAPER AWARDS

Agriculture, Forestry and Aquaculture Science

Best Student Paper
Lettie C. Lawrence, Department of Biology, Virginia Commonwealth University. Structure and Material Properties of Swimbladders Mediating Ultrasound Production.

Honorable Mention
B. Prall and M. A. Cline, Department of Biology, Radford University. Stresscopin Causes Anorexigenic Effects in Chicks.

Astronomy, Mathematics and Physics & Materials Science

Best Student Paper
Olusola Oyebola. Department of Physics, Hampton University. Infrared Spectroscopy of Holmium Doped KPb_2Cl_5 for Laser Applications.

Honorable Mention
E. Brown Hanley, Department of Physics, Hampton University. Near Infrared Emission Properties of Er: YAG Ceramic, Er: KPb_2Cl_5 and Er: KPb_2Cl_5 for 1.5-1.6 μm eye-safe solid-state lasers.

Honorable Mention
Bruno Caputo, Department of Physics, Hampton University. Promotion of Metal Thin-Film Adhesion on Polymer Substrates.

Biology

Best Student Paper-Graduate
M. R. Semcheski, Department of Biological Sciences, Old Dominion University, Norfolk, VA. Phylogenetic Relationships of the Snappers (*Lutjanidae: Percoidei*) Inferred from Mitochondrial Cytochrome b Sequence Data.

Honorable Mention-Graduate
T. A. Egerton, Department of Biological Sciences, Old Dominion University, Norfolk, VA. Exploration of Phytoplankton Communities in Southeastern Virginia for Use in Biodiesel Production.

Best Student Paper-Undergraduate
Brian Prall, Department of Biology, Radford, University. Differential Appetite-Related Responses to Central Neuropeptide S in Lines of Chickens Divergently Selected for Low or High Body Weight.

Honorable Mention-Undergraduate
Ludmila Francescatto, Dept. of Biology, Virginia Commonwealth University. The Role of CaMK-II Beta2 in the Cardiac Development in Zebrafish.

Best Student Poster
W. Calchary, Dept. of Biology, Radford University. Central Calcitonin Gene Related Peptide Causes Hypothalamic Associated Anorectic Responses in *Gallus gallus*.

Biomedical and General Engineering

Best Student Paper
Patrick C. Headley, Dept. of Biomedical Engineeering, Virginia Commonwealth University. Possibilities for a Pressure and Processing Approach to the Recognion of Pressure Ulcer Formation.

Honorable Mention
Justin M. Owen, Dept. of Biomedical Engineeering, Virginia Commonwealth University. Designing a Quiet Vehicle Avoidance System for the Blind and Visually Impaired.

Botany

Best Student Paper
L. E. Deliman, Dept. of Biology, James Madison University. Antioxidant Activity in Selected Domestic and Imported Wines.

Honorable Mention
K. A. Carlson-Drexler , Dept. of Biology, W illiam & Mary. Pre- and Post-Hurricane Composition in a Hardwood Forest.

Computer Science

Best Student Paper
Syed R. Rizvi, Dept. of Computer Science, Old Dominion University. Design and Simulation of Smart Emergency Service Vehicles using Vehicular Ad Hoc Networks.

Natural History & Biodiversity

Best Student Paper
Nuno Prista, Centro de Oceanografia, Faculdade de Ciências da Universidade de Lisboa, Lisboa, Portugal. Using tags to sample large valuable fish.

Honorable Mention
Joseph C. Ballenger, Jones, Center for Quantitative Fisheries Ecology, Department of Ocean, Earth, and Atmospheric Sciences, Old Dominion University. Length-Weight, Age and Growth of Sheepshead (*Archosargus probatocephalus*) of Chesapeake Bay, Virginia: A Comparison to Other Areas.

Psychology

Best Student Paper
S.A. Vunck,, Department of Psychology, Virginia Commonwealth University. Discriminative Stimulus Properties of the glutamate agonist N-methyl D-aspartate (NMDA) in C57BL/6 mice.

Honorable Mention
Natasha L. Golden, Department of Psychology, Old Dominion University. The Cognitive and Behavioral Effects of Acute Ethanol Administration and Withdrawal.

Honorable Mention
M.R.Pearson, Department of Psychology, Old Dominion University. Time Perspective and Risky Behavior: Moderating Effects of Religiosity.

Statistics

Best Student Paper
Corinne Wilson, Department of Mathematics and
Statistics, Old Dominion University. A Comparison of Different Methods for Predicting Cancer Mortality Counts at the State Level.

Honorable Mention
Abdel-Salam G. Abdel-Salam, Virginia Polytechnic Institute and State University. Profile Monitoring Analysis Using Semiparametric Methods.

VIRGINIA JUNIOR ACADEMY OF SCIENCE
2008 AWARDS

AGRICULTURE AND ANIMAL SCIENCE

Honorable Mention:	STACEY R. BEAM Piedmont Governor's School
Honorable Mention:	DAVID M. GREEN, JR. Chesapeake Bay Governor's School
Third Place:	MARK C. GORDON Hermitage High School
Second Place:	JESSIE C. CAPPELLO Lee-Davis High School
First Place:	KATHERINE M. ABRAMS Southwest Virginia Governor's School

ANIMAL BEHAVIOR (ETHOLOGY)

Honorable Mention:	JULIE O. GRISSOM Chesapeake Bay Governor's School
Honorable Mention:	CARINE L. SQUIBB Southwest Virginia Governor's School
Honorable Mention:	BENJAMIN TERNER Mills E. Godwin High School
Third Place:	RACHEL D. AKERS Chesapeake Bay Governor's School
Second Place:	COURTNIE A. BOWIE Chesapeake Bay Governor's School
First Place:	JOSHUA D. DEGASTYNE Southwest Virginia Governor's School

BOTANY A

Honorable Mention:	EMILY A. BONIFACE Central Virginia Governor's School
Honorable Mention:	ANN M. CARROLL Central Virginia Governor's School
Honorable Mention:	KAYLA A. JOHNSON Central Virginia Governor's School
Third Place:	SE W. JEONG Roanoke Valley Governor's School
Second Place:	SARAH HAKKENBERG Roanoke Valley Governor's School
First Place:	ANNA M. BROSNAHAN Washington-Lee High School

BOTANY B

Honorable Mention:	SARAH G. MURPHY George H. Moody Middle School
Honorable Mention:	CHRISTINA S. PHANG Washington-Lee High School
Honorable Mention:	NORVELL W. WEST, IV Roanoke Valley Governor's School
Third Place:	CHRISTINE G. LEE AND JASTEENA K. GILL Thomas Jefferson High School for Science and Technology
Second Place:	RICHARD METZGER, JOHN DEEMY AND ANDERSON SATTERWHITE Chesapeake Bay Governor's School
First Place:	KATHERINE E. MIZE Galileo Magnet High School

CHEMISTRY A

Honorable Mention:	ABIGAIL K. BESSLER Williamsburg Middle School
Honorable Mention:	MATTHEW O. ERNESTO Yorktown High School
Honorable Mention:	CAROLYN A. FONZI Bishop Denis J. O'Connell High School
Third Place:	LILLY L. BOULDIN Washington-Lee High School
Second Place:	ROSS M. BRAGG Atlee High School
First Place:	CAROLINE M. BIRASA Washington-Lee High School

CHEMISTRY B

Honorable Mention:	THOMAS E. MIOTKE Washington-Lee High School
Honorable Mention:	BILLY F. MOORE Southwest Virginia Governor's School
Honorable Mention:	CORINNE E. WIESNER Washington-Lee High School
Third Place:	JOCELYN F. KEATTS Shenandoah Valley Governor's School
Second Place:	SAMEER M. SARKAR George H. Moody Middle School
First Place:	AMANDA K. RODGERS Southwest Virginia Governor's School

COMPUTER SCIENCE

Honorable Mention:	DANIEL L. QUILLEN Shenandoah Valley Governor's School
Third Place:	BEN M. ROBLE Mathematics and Science High School at Clover Hill
Second Place:	PRAKRITI VERMA New Horizons Governor's School
First Place:	BENJAMIN S. HUGHES Piedmont Governor's School

CONSUMER SCIENCE A

Honorable Mention:	JOSEPH B. DAVIS Patrick Henry High School
Third Place:	MICHAEL J. DANIELS Gildersleeve Middle School
Second Place:	YA-RU CHEN Shenandoah Valley Governor's School
First Place:	ZOE K. ALTHOLZ Atlee High School

CONSUMER SCIENCE B

Honorable Mention:	MADALYN L. MARSHALL Shenandoah Valley Governor's School
Honorable Mention:	JENNIFER E. PAUCKE AND CHRISTINA A. SWANSON Deep Run High School
Honorable Mention:	ZACHARY A. SUMNER Shenandoah Valley Governor's School

Third Place:	EMMA K. THORP Washington-Lee High School
Second Place:	EVAN T. UNDERWOOD Shenandoah Valley Governor's School
First Place:	STEVEN A. WEBB Central Virginia Governor's School

EARTH AND SPACE SCIENCE

Honorable Mention:	ALEC R. BRENNER Longfellow Middle School
Honorable Mention:	BRANDEN T. KATONA Mills E. Godwin High School
Third Place:	ARYA DAHAL Williamsburg Middle School
Second Place:	DANIEL J. LEIBOVIC George H. Moody Middle School
First Place:	ELIZABETH M. THOMAS Southwest Virginia Governor's School

ENGINEERING A

Honorable Mention:	CLIFFORD M. BOYD North Cross School
Honorable Mention:	KATHARINE A. GRAHAM George H. Moody Middle School
Honorable Mention:	JONATHAN H. GUINTHER Mills E. Godwin High School
Third Place:	ANDREA L. GINGRICH Central Virginia Governor's School

Second Place:	ROBERT BRIK Mills E. Godwin High School
First Place:	SAMANTHA R. DAUER Central Virginia Governor's School

ENGINEERING B

Honorable Mention	JOSHUA G. LEVINSON Central Virginia Governor's School
Honorable Mention:	BRADFORD W. MCGANN Washington-Lee High School
Honorable Mention:	RACHEL C. WILBUR Gildersleeve Middle School
Third Place:	TINA SONG Central Virginia Governor's School
Second Place:	BRITTANY A. MARTINEZ James River High School
First Place:	KIRSTEN F. RUMSEY Menchville High School

ENVIRONMENTAL SCIENCE A

Honorable Mention:	JULIA M. ARONSON Shenandoah Valley Governor's School
Honorable Mention:	MATTHEW S. CARPENTER Central Virginia Governor's School
Honorable Mention:	SUCHANA H. COSTA Washington-Lee High School
Third Place:	STEPHANIE K. DAHLEM Chesapeake Bay Governor's School
Second Place:	CHRISTINA N. CHENG AND KRISTEN E. SLAUGHTER Chesapeake Bay Governor's School

First Place: AMRITA BANERJEE
Mills E. Godwin High School

ENVIRONMENTAL SCIENCE B

Honorable Mention: MORGAN L. FAULKNER
Chesapeake Bay Governor's School

Honorable Mention: GEORGE S. GIANAKOS
Central Virginia Governor's School

Honorable Mention: MARINA K. GIRGIS
George H. Moody Middle School

Third Place: AMANDA N. GRANT AND
CHELSEA A. LIVINGSTON
Deep Run High School

Second Place: LINDSAY J. HUNDLEY
Chesapeake Bay Governor's School

First Place: STACEY L. HOUSTON
Central Virginia Governor's School

ENVIRONMENTAL SCIENCE C

Honorable Mention: JAMIE L. JOHNSON AND
CHELSEA L. REED
Chesapeake Bay Governor's School

Honorable Mention: ALEX B. JONES
Washington-Lee High School

Honorable Mention: SAMANTHA PIERSON,
LOWERY PEMBERTON AND
WAYNE LAMKIN
Chesapeake Bay Governor's School

Third Place: KASEY E. PHILLIPS
Chesapeake Bay Governor's School

Second Place: STEPHANIE A. MARQUEEN
Douglas Freeman High School

First Place:	BRYSON R. KEMLER Hanover High School

ENVIRONMENTAL SCIENCE D

Honorable Mention:	ZACHARY K. SCHARF Central Virginia Governor's School
Honorable Mention:	SHANNA SU Mills E. Godwin High School
Honorable Mention:	ROSS SUMNER, KELSI JEWELL AND JESSICA VANECEK Chesapeake Bay Governor's School
Third Place:	GEORGE H. SYDNOR New Horizons Governor's School
Second Place:	STEPHANIE M. UMPHLETTE Chesapeake Bay Governor's School
First Place:	JACOB S. VROOMAN Chesapeake Bay Governor's School

GENETICS AND CELLULAR BIOLOGY

Honorable Mention:	SARAH Y. HOUAMED George H. Moody Middle School
Honorable Mention:	EDWARD S. RICE Thomas Jefferson High School for Science and Technology
Honorable Mention:	CAROLYN SONG Mills E. Godwin High School
Third Place:	ALEXANDER TURRO Bishop Denis J. O'Connell High School
Second Place:	SURAJ K. MISHRA Mills E. Godwin High School

First Place: ERIN D. KIM
Mathematics and Science High School at Clover Hill

MATHEMATICS

Honorable Mention: PATRICK W. MAHANEY
Southwest Virginia Governor's School

Honorable Mention: AUDREY E. POE
Shenandoah Valley Governor's School

Honorable Mention: ZACHARY TERNER
Mills E. Godwin High School

Third Place: ABDULLAH A. FARHAT
Kecoughtan High School

Second Place: XUANYI CHEN
Southwest Virginia Governor's School

First Place: PHILIP S. CHODROW
Shenandoah Valley Governor's School

MEDICINE AND HEALTH A

Honorable Mention: INESHA PREMARATNE, SARAH BOOTH AND NILUFAR MIRSHAHI
Henrico High School

Honorable Mention: DONNA Y. REA
Piedmont Governor's School

Honorable Mention: JEFFREY L. ROBERSON
Atlee High School

Third Place: XIAOXIAO ZHANG
Mills E. Godwin High School

Second Place: TIM XU
Thomas Jefferson High School for Science and Technology

First Place:	VIRGINIA E. PHILLIPPE Central Virginia Governor's School

MEDICINE AND HEALTH B

Honorable Mention:	BRADLEY T. GOOD Shenandoah Valley Governor's School
Honorable Mention:	ANGELA C. MENNA Mills E. Godwin High School
Honorable Mention:	KATELYN E. MILAM Central Virginia Governor's School
Third Place:	JESSICA W. LAU Mills E. Godwin High School
Second Place:	HANNAH R.B. MEREDITH Mathematics and Science High School at Clover Hill
First Place:	SAPPHO Z. GILBERT Thomas Jefferson High School for Science and Technology

MICROBIOLOGY A

Honorable Mention:	LAUREN E. BENNETT George H. Moody Middle School
Honorable Mention:	HANTING FENG Mathematics and Science High School at Clover Hill
Honorable Mention:	ALICE S. KIM Mathematics and Science High School at Clover Hill
Third Place:	JEWEL C. LLAMAS Central Virginia Governor's School

Second Place: PARKER D. VASCIK
Roanoke Valley Governor's School

First Place: SEANA HEDAYATNIA
Mills E. Godwin High School

PHYSICAL SCIENCE

Honorable Mention: BRANDON M. BUNCHER
George H. Moody Middle School

Honorable Mention: ROHAN PIDAPARTI
George H. Moody Middle School

Honorable Mention: WILLIAM J. YOUNG
Williamsburg Middle School

Third Place: JESSE F. FERRELL
Swanson Middle School

Second Place: JESSICA M. LITZ
Chickahominy Middle School

First Place: AZEB YIRGA
George H. Moody Middle School

PHYSICS A

Honorable Mention: IAN H. FEENEY
Washington-Lee High School

Honorable Mention: KYLE P. TENNY
Central Virginia Governor's School

Honorable Mention: NICOLAS M. ZEVALLOS
Washington-Lee High School

Third Place: DAVID C. LEMERY
Galileo Magnet High School

Second Place:	WADE D. HODSON Homer L. Hines Middle School
First Place:	VIJAY GOVINDARAJAN Mills E. Godwin High School

PSYCHOLOGY - GENERAL

Honorable Mention:	MEAGAN C. JENIGAN Appomattox Governor's School
Honorable Mention:	MADELEINE A. SENDEK Swanson Middle School
Honorable Mention:	JOSEPH D. WALLACE AND ABIGAIL E. WALLACE Chesapeake Bay Governor's School
Third Place:	ANDREW P. BROWN Yorktown High School
Second Place:	KATHERINE CHEN George H. Moody Middle School
First Place:	ALLYSON M. GARDNER Piedmont Governor's School

PSYCHOLOGY - LEARNING & PERCEPTION A

Honorable Mention:	JUSTIN I. CASTILLO Chesapeake Bay Governor's School
Honorable Mention:	ERIC J. ALVAREZ Washington-Lee High School
Honorable Mention:	BRANDON W. HYLTON Piedmont Governor's School
Third Place:	AARON D. BERNEKING Shenandoah Valley Governor's School

Second Place:	LISA M. CARTER Chesapeake Bay Governor's School
First Place:	BENJAMIN V. KARAUS Central Virginia Governor's School

PSYCHOLOGY - LEARNING & PERCEPTION B

Honorable Mention:	AMANDA M. WASHBURN Piedmont Governor's School
Honorable Mention:	CASEY L. WASHBURN Piedmont Governor's School
Honorable Mention:	JESSICA N. WHITE Central Virginia Governor's School
Third Place:	BRITNI C. MARTIN Washington-Lee High School
Second Place:	BHAUMIK P. PATEL Central Virginia Governor's School
First Place:	AMELIA J. TYLER Southwest Virginia Governor's School

PSYCHOLOGY - SOCIAL

Honorable Mention:	THOMAS W. DICKINSON Washington-Lee High School
Honorable Mention:	RACHEL E. OBENSCHAIN Shenandoah Valley Governor's School
Third Place:	SAM J. BOWMAN Shenandoah Valley Governor's School
Second Place:	STEPHANIE A. PAINTER Shenandoah Valley Governor's School
First Place:	CHARLES N. GOWAN Atlee High School

STATISTICS

Honorable Mention:	LAYSA HEDJAR Shenandoah Valley Governor's School
Honorable Mention:	TIMOTHY J. MEADORS Southwest Virginia Governor's School
Honorable Mention:	MARY H. WHITESELL Shenandoah Valley Governor's School
Third Place:	ROY B. POWELL Washington-Lee High School
Second Place:	ANDREW G. YOUNG AND GIRIKARNIKA JAMMI Mills E. Godwin High School
First Place:	AJAY R. SUNDAR Mills E. Godwin High School

ZOOLOGY

Honorable Mention:	JERRY T. PRICE Central Virginia Governor's School
Honorable Mention:	HOWARD C. RAY, III Central Virginia Governor's School
Honorable Mention:	GRACE C. WANG AND VICTORIA L. ZUPAN Thomas Jefferson High School for Science and Technology
Third Place:	NATALIE M. CLARK Central Virginia Governor's School
Second Place:	AMELIA R. GONZALEZ AND RAQUEL M. TRIPP Thomas Jefferson High School for Science and Technology

First Place:

ADRIANA M. PHILLIPS AND
SYDNEY P. SCHRIDER
Thomas Jefferson High School for Science and Technology

SPECIAL AWARDS

Botany Section Award, given by the Botany Section of the VAS, to the best paper on a botanical subject.

KATHERINE E. MIZE
Galileo Magnate High School

VJAS Neuroscience Awards supported by the Virginia Neurological Society is given to an out-standing paper in the field of neuroscience.

JOSHUA DEGASTYNE
Southwest Virginia Governor's School

Speleological Society Award given to the best paper addressing karst or topics related to speleology given by the Richmond Area Speleological Society.

No applicants this year.

Mathematics Award for the paper that evidences the most significant contribution in the field of Mathematics.

PHILLIP CHODROW
Shenandoah Valley Governor's School

Statistics Award for the paper that evidences the most significant contribution in the field of Statistics.

AJAY R. SUNDAR
Mills E. Godwin High School

Smith Shadomy Infectious Disease Award in honor and memory of Dr. Smith Shadomy given by the Virginia Chapter of the National Foundation of Infectious Diseases.

TARA ADISESHAN
Ramana Academy

Roscoe Hughes Award for the best paper in the field of Cellular Biology.

ERIN KIM
Mathematics and Science High School at Clover Hill

Rodney C. Berry Chemistry Award for the paper that evidences the most significant contribution in the field of chemistry.

AMANDA K. RODGERS
Southwest Virginia Governor's School

The Dr. and Mrs. Preston H. Leake Award in Applied Chemistry will be given to the author of a research paper which best exemplifies how chemicals, chemical principles, or chemistry have been used, are used, or might be used to enhance or even to save life.

Second Place	PRASANNA G. JOSHI George H. Moody Middle School
First Place	ERIN KIM Mathematics and Science High School at Clover Hill

Russell J. Rowlett Award for the Best Research Paper of the Year.

PHILIP CHODROW
Shenandoah Valley Governor's School

The Virginia Psychological Foundation Meritorious Research Awards recognize outstanding presentations of research in the various fields of psychology.

ALLYSON M. GARDNER
Piedmont Governor's School

BENJAMIN B. KARAUS
Central Virginia Governor's School

AMELIA J. TYLER
Southwest Virginia Governor's School

CHARLES N. GOWAN
Shenandoah Valley Governor's School

Virginia Sea Grant College Program Award is given by the Virginia Sea Grant College Program for outstanding marine or coastal research.

KASEY E. PHILLIPS
Chesapeake Bay Governor's School

American Cancer Society Award - This award is to recognize outstanding science papers related to cancer research.

Second Place
CAROLYN SONG
Mills E. Godwin High School

Second Place
SURAJ K. MISHRA
Mills E. Godwin High School

First Place
SAPPHO ZOE GILBERT
Thomas Jefferson High School for Science and Technology

The Gamma Sigma Delta Award (Agriculture). Presented by the VPI & SU Chapter of the Honor Society of Agriculture. This award is presented in recognition of excellence in research dealing with application of new technologies and/or concepts in agriculture forestry, or veterinary medicine.

KATHERINE M. ABRAMS
Southwest Virginia Governor's School

Dominion - W.W. Berry Award. This award is given by Dominion Virginia Power in honor of Mr. W. W. Berry who was a past Chairman of the Board of VA Power. This award of a $500.00 Savings Bond will be presented to the best engineering paper.

SAMANTHA DAUER
Central Virginia Governor's School

The Joyce K. Peterson Award is presented for the outstanding paper by a middle school student. It is presented in honor of Mrs. Joyce K. Peterson who has been an outstanding teacher in the Arlington County Schools.

PRASANNA G. JOSHI
George H. Moody Middle School

The Ann M. Hancock Award - This award is given to the best paper in genetics and is given in memory of Anne Hancock who retired from Patrick Henry High School in Hanover County and who gave many years of service to the Jr. Academy not only by teaching but also serving on the Jr. Academy Committee.

SURAJ MISHRA
Mills E. Godwin High School

Dorothy Knowlton Award - This award is given to the best paper in the Consumer Science section(s) and is given in honor of Dorothy Knowlton, former Science Coordinator of Arlington County Schools.

Not awarded this year

VABE Award - This award is presented by the Virginia Association of Biology Educators and is given for outstanding research in the Zoology section.

ADRIANA M. PHILLIPS AND SYDNEY P. SCHRIDER
Thomas Jefferson High School for Science and Technology

Virginia Museum of Natural History Award - Presented by The Virginia Museum of Natural History Foundation in recognition of significant contribution in the study and interpretation of Virginia's Natural Heritage.

STEPHANIE M. UMPHLETTE
Chesapeake Bay Governor's School

Trip to AJAS - AAAS Meeting for two students for presenting outstanding papers. The 2009 meeting will be held in Feb.in Chicargo.

winner — AMANDA K. RODGERS
Southwest Virginia Governor's School

winner — SAPPHO Z. GILBERT
Thomas Jefferson High School for Science and Technology

Honorary Membership - AAAS.

FELICIA HOLZGREFE
Atlee High School

Honorary Membership - VAS given to a student.

BRENDAN DOLYE
Yorktown High School

Bethel High School Scholarship - This $1,000 Scholarship Award comes from the interest earned from a $10,000 endowment contributed by the students of Bethel High School, Hampton, Va., over a two year period. This award is based on both the students presentation and paper.

No Winner this Year

Henry MacKenzie Environmental Scholarship - This $5,000 scholarship will be awarded to the student whose paper evidences the most significant contribution in the field of Environmental Science dealing with the James River Basin and Chesapeake Bay. The Virginia Endowment and VJAS offer this scholarship in tribute to the outstanding and generous services of Judge Henry W. MacKenzie, Jr., one of the founding directors who has a great interest in the James River and the Chesapeake Bay.

GEORGE SYDNOR
New Horizons Governor's School

Frances and Sydney Lewis Environmental Scholarship: A $14,000 scholarship ($3,500 per year for four years) for the best effort by a student in grades 9 to 12 in the field of environmental science. This scholarship is in the name of Frances and Sydney Lewis and is given by the Virginia Environmental Endowment.

JACOB S. VROOMAN
Chesapeake Bay Governor's School

E.C.L. Miller Science Teacher of the Year Award is given to an outstanding science teacher. An all-expense-paid trip to the next VAST meeting held in November.

RYAN THOMAS TEMPLETON
Mathematics and Science High School at Clover Hill

VJAS Distinguished Service Award.

Not awarded this year.

New Student Officers

Historian - TREVER OTTOFARO, New Horizons Governor's School
Secretary - ELIZABETH GENTRY, Atlee High School
Vice President - TARA ADISESHAN, Ramana Academy
President - PRAKRITI VERMA, New Horizons Governor's School

Our meeting next year will be at Virginia Commonwealth University, in Richmond.

AUTHOR INDEX

NOTES

VIRGINIA ACADEMY OF SCIENCE

APPLICATION FOR MEMBERSHIP

Name (Please Print) _____

Home Phone _(____)_____

Office Phone _(____)_____

E-mail _____

Address _____

City _____ State _____ Zip _____

Institution or Business _____

Position -- Title _____

Interest -- Section No.(s) _____ First no. indicates major interest

Contacted by: _____

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Dinoflagellate Cysts within Sediment Collections from the southern Chesapeake Bay, and Tidal Regions of the James, York, and Rappahannock Rivers, Virginia.

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Dinocysts, Chesapeake Bay, Virginia

ABSTRACT

The upper 2 cm of sediment core samples from 70 stations in the tidal waters of three Virginia rivers and at 23 stations in the lower Chesapeake Bay were sampled for dinoflagellate cysts. The river sediment cysts were dominated by three common bloom producing species (*Heterocapsa triquetra, Scrippsiella trochoidea,* and *Cochlodinium polykrikoides*), whereas these were in low concentration in the Chesapeake Bay sediments which contained mainly dinoflagellate cysts of neritic and oceanic taxa. The mean sediment concentrations from stations in the James, York, and Rappahannock rivers were respectively 1174.8, 536.2, and 323.6 cysts g^{-1}. The mean cyst concentration in the Chesapeake Bay sediment was 714.8 g^{-1}. Cysts of 2 potentially harmful species were recorded from the sediment, with the river sediments identified as seed beds and a source for re-occurring algal blooms in these waters.

INTRODUCTION

Dinoflagellates are common components of the phytoplankton flora of the Chesapeake Bay estuarine complex with ca. 190 dinoflagellate taxa reported in these waters (Marshall et al. 2005). The life cycles for many of these species include a dominant vegetative stage consisting of a motile planktonic zoospore, cells associated with reproduction, in addition to the formation of a temporary non-motile and dormant stage when a cyst is formed. These cysts (dinocysts) may settle in the sediment where they remain viable for variable periods of time, and with many subsequently activated to excyst and form motile cells that will continue their development in the water column. Due to the resistant nature of these cysts to decay, many that do not excyst will remain basically unchanged morphologically, and often become fossil representatives of waters that overlaid these substrates. Historical distribution records for dinoflagellate cysts, relict diatoms and their changing composition over time have been determined from Chesapeake Bay sediment samples (Brush 1984; Cooper 1995; Willard et al. 2003). Studies of fossil dinoflagellate cysts have been conducted by both paleontologists and phycologists with each originally using a different approach in cyst classification. This produced contrasting nomenclature in the literature and a dual classification system (de Verteuil and Norris 1996a). Additional confusion in

identification may come from morphological variability among the cysts in the various strains of these taxa.

Early records from Miocene sediment deposits of dinoflagellate cysts from the Chesapeake Group have been reported by de Verteuil and Norris (1996a, b). They indicated abundance levels for various taxa at sites in the Chesapeake Bay. Edwards and Powars (2003) discussed damage to dinocysts in Chesapeake Bay sediment that occurred during the late Eocene when a meteorite struck this region. Using late-Holocene sediment records, Willard et al. (2003) related dinocysts and pollen presence to climate changes that have occurred in this region. Data from other core sediments in the lower Chesapeake Bay were included in a broader oceanic study by Wall et al. (1977), in addition to Tyler et al. (1982) in the Potomac River. Wall et al. (1977) described cyst representation in an extensive examination of surface sediments from the United States Atlantic coast. In their study, the dominant taxa at the Chesapeake Bay entrance were *Operculodinium centrocarpum* (Deflandre and Cookson) Wall, *Peridinium* spp., *Spiniferites elongatus* Reid, and *Spiniferites mirabilis* (Rossignol) Sargeant. They associated these taxa with temperate estuaries that were moderately stratified to salinity values that were lower when compared to adjoining coastal waters. *Operculodinium centrocarpum* was also the most abundant sediment cyst in estuaries north of Cape Hatteras, whereas, the southern distribution limit of *S. elongatus* was Chesapeake Bay. Other common species included *Spiniferites bulloideus* (Deflandre and Cookson) Sargeant and *Spiniferites ramosus* (Ehrenberg) Loeblich and Loeblich. Using botanical terminology, the *Spiniferites* group would likely be placed in a *Gonyaulax* "complex", with a major component composed of either *Gonyaulax spinifera* (Claparede & Lachmann) Diesing, or *G. scrippsae* Kofoid, or both of these. In botanical nomenclature, *O. centrocarpum* has been placed within the *Protoceratium reticulatum* (*Gonyaulax grindleyi*) group (Wall et al. 1977) and *Peridinium* spp. as *Protoperidinium* spp.

The maximum number of species Wall et al. (1977) found in any one sample was 20, with cyst density in the estuarine and shelf sediments along the northeastern United States ranging from ca. 1,000 to less than 5,000 cysts g^{-1}sediment. In contrast to emphasizing a broad array of different cysts in the sediment, Tyler et al. (1982) described bloom occurrence and encystment of the dinoflagellate *Gyrodinium uncatenum* Hulburt in the Potomac River, Virginia. They identified physical forces within the river that influenced the distribution of the cysts following bloom conditions. These include the subsequent transport of these cells below the pycnocline to a benthic frontal region upstream and settling in the river sediment. This indicated numerous seed beds within the river that are available to subsequently repopulate the water column. During their sediment analysis they noted the greatest cyst abundance occurred within the upper 4 cm of the sediment, with highest concentrations in the upper 2 cm. The number of *G. uncatenum* cysts in the upper 4 cm from 9 stations ranged from 1 to 280 cysts cm^{-3}. High species diversity among dinoflagellate cysts have frequently been reported from sediment deposits. For instance, Godhe et al. (2000) recorded 43 cyst taxa of which 38 belonged to the Gonyaulacales from southwest India, and Joyce (2004) identified 26 dinocyst types from the Scapa Flow, Orkney, Scotland (composed

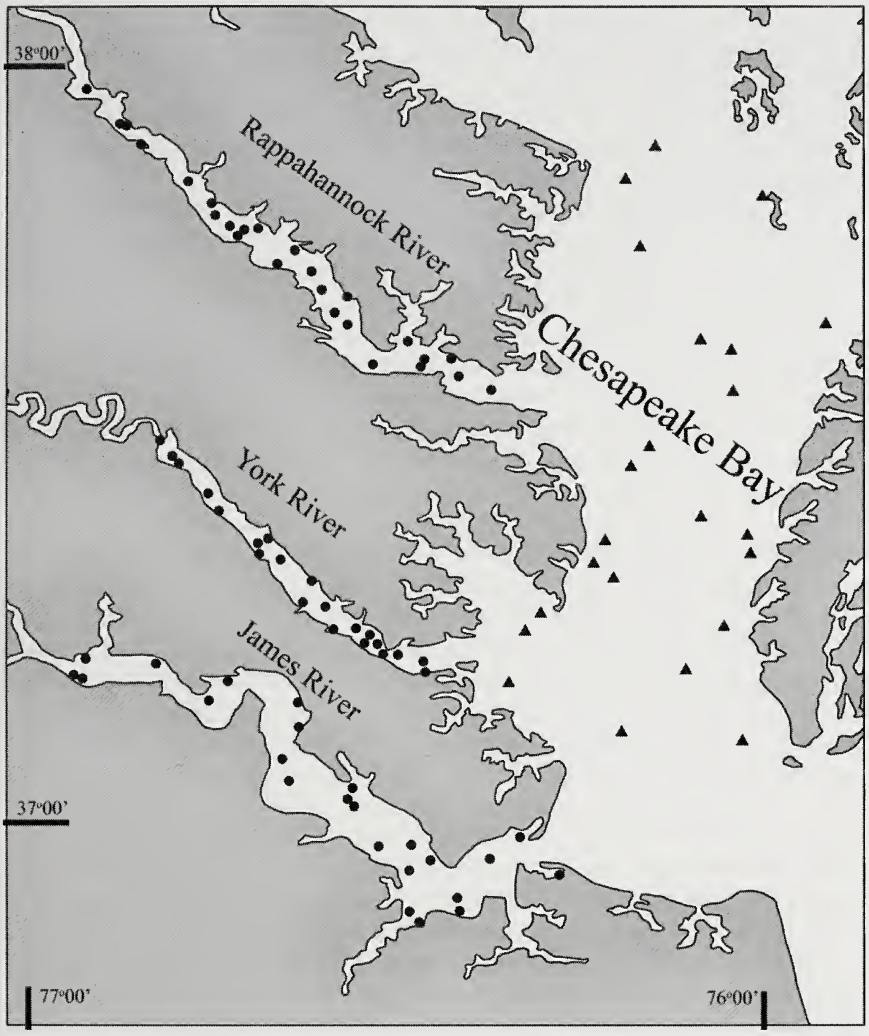

FIGURE 1. Location of sites where sediment samples were taken in the Chesapeake Bay (▲), and the James, York, and Rappahannock rivers (●) during August/September 1996.

mainly of Gonyaulacales, Gymnodiniales, and Peridiniales), with their abundance from 12 stations ranging from 37 to 1524 cysts ml^{-1} wet sediment.

The objectives of this paper are to examine the presence, composition, and abundance of dinoflagellate cysts in sediment samples from locations in the southern region of Chesapeake Bay, and from three of its major Virginia tributaries (the James, York, and Rappahannock rivers).

MATERIALS AND METHODS

The sediment samples for this study were taken during August and September 1996 from a random selection of 23 stations within the southern portion of Chesapeake Bay and 70 stations in the James (24), York (21), and Rappahannock (25) rivers (Fig. 1). Several additional sites were sampled, but found incompatible for sediment retrieval due to their locations within oyster beds. Salinity and water temperature readings were taken when on station during sediment collections. These collections were made aboard the Old Dominion University R/V Linwood Holton using a box corer driven into the sediment with attached lead weights. Upon return to the ship's deck, plastic cylinders, 3 cm in diameter and 10 cm in length, were inserted 5 cm into the sediment. These cylinders were capped, and stored in darkness at 4°C. The upper 2 cm were subsequently processed for microscopic analysis according to Yamaguchi et al. (1995). Five gram (wet weight) aliquots of these sediment samples were suspended in distilled water and sonicated for 10 seconds to disaggregate the cysts from particulate matter, with the suspension passed through a series of sieves to a final size fraction of 10 μm that included cysts. This material was collected and washed with 5 ml aliquots transferred to a 15 ml centrifuge tube, with 1% glutaraldehyde added for fixation (30 minutes), then centrifuged for 15 minutes (700 x g), with the supernatant discarded. One ml of a stock solution of the fluorochrome primuline was added to this product and left in the dark for 1 hour. After storage, the supernatant containing the fluorochrome was discarded. The pellets were re-suspended in distilled water and centrifuged for washing, then re-suspended in 5 ml distilled water. Aliquots of the stained sediment suspension were transferred to a counting chamber using fluorescence microscopy for cyst analysis. The cysts were recorded as numbers g^{-1} sediment (wet), and as percentage of cysts collected.

RESULTS

Surface water temperatures during the periods of collection for both the river and Chesapeake Bay stations were from 24.0 to 29.4 °C. The surface salinity ranged from 1.2 to 22.8 ppt in the James River, 5.0 to 17.7 ppt in the Rappahannock River, and 15.2 to 22.0 ppt in the York River. The Bay station salinities were mainly polyhaline, ranging from 17.2 ppt southward to higher salinities near the Bay entrance (e.g. 27.0 ppt). Station depths for sampling the river sediment varied considerably. These included shallow, near shore regions of ca. 1.1 m (James) to mid-channel depths of 25.0 m (Rappahannock). In the lower Bay, sampling site depths ranged from 2.7 to 29.7 m.

TABLE 1. Mean percentage of total dinocysts from sediment samples taken at stations in the Rappahannock, York, and James rivers, and southern stations in Chesapeake Bay during August/September 1996.

Common Cyst Producers	Rapp.	York	James	Bay
Heterocapsa triquetra	69.5	57.8	73.4	1.6
Gonyaulax "complex"	1.4	3.3	3.7	67.3
Cochlodinium polykrikoides	0.5	21.7	8.2	0.2
Polykrikos kofoidii	4.4	3.3	7.0	4.9
Scrippsiella trochoidea	4.1	3.8	2.7	2.2
Protoperidinium spp.	1.7	2.0	1.0	8.6
Gyrodinium spp.	-	1.1	0.1	0.5
Pyrodinium bahamense v. *compressum*	-	-	-	0.1
Pyrophacus horologium	-	-	-	0.1
Unidentified dinocysts	18.4	7.0	3.9	14.5

The representation of cysts (percentage of the total) from the major taxon categories is listed in Table 1. Botanical protocols were followed for cyst identifications in contrast to those used in paleontological listings. The mean station concentrations in these rivers were 1,174.8, 536.2, and 323.6 cysts g^{-1} sediment respectively for the James, York, and Rappahannock rivers. The most common cysts within the river sediments were those of *Heterocapsa triquetra* (Ehrenberg) Stein, a common bloom producer in these rivers (Marshall et al. 2005). It represented 73.4 and 69.5 % of the cysts in the James and Rappahannock rivers, and 57.8 % in the York (Table 1). Other annual bloom producers having abundant cysts in the river sediments included *Cochlodinium polykrikoides* Margelef, *Scrippsiella trochoidea* (Stein) Loeblich and *Polykrikos kofoidii* Chatton. Of these, cysts of *C. polykrikoides* were especially abundant in the York and James rivers, representing 21.7 and 8.2 % of the total cysts in sediment from these rivers. Cysts within the Bay sediments were mainly of coastal and oceanic species, and included a *Gonyaulax* "complex" and a *Protoperidinium* spp.group, both less noted in the river sediments. Cyst concentrations of the common river species had very low representation in the Bay, e.g. *Heterocapsa triquetra* represented only 1.6% of the cysts in the Bay sediments. Within both river and Bay samples there were also unidentified dinoflagellate cysts.

Cyst concentrations in the three rivers ranged from 15 to 4,970, 95 to 1,250, and 50 to 645 g^{-1} sediment respectively, for the James, York, and Rappahannock rivers. Higher cyst concentrations in the James River occurred at its downstream stations, with their numbers decreasing moving upstream to the lower salinity (< 12 ppt) locations. A similar decrease in cyst abundance occurred at the upstream stations in the York and Rappahannock rivers.

The mean cyst concentration in Chesapeake Bay was 714.8 g^{-1}sediment. The highest numbers (10^3 g^{-1}) occurred at the more saline stations closest to the Bay entrance, with peak abundance at 2,165 cysts g^{-1}sediment. These concentrations decreased moving northward in the Bay where abundance levels were ca. 200 to 600 cysts g^{-1}. The greatest representation of cysts in the Bay sediment came from the *Gonyaulax* "complex" (67.3 %), and a *Protoperidinium* spp. group (8.6%), which were

represented by a variety of oceanic/coastal species. These included: *Gonyaulax* spp., *Gyrodinium* spp., *Protoperidinium conicum* (Gran) Balech, *P. depressum* (Bailey) Balech, *P. leonis* (Pavillard) Balech, and *P. pentagonum* (Gran) Balech. Other taxa noted in the Bay sediment included *Pyrodinium bahamense* v. *compressum* (Böhn) Steidinger and *Pyrophacus horologium* Stein. In general, coastal and oceanic taxa cyst abundance was greatest at the Bay entrance, and decreased moving northward in the Bay. Less numerous in Chesapeake Bay sediments were cysts of taxa that were common in the river sediment. These were *Scrippsiella trochoidea*, *Heterocapsa triquetra*, and *Cochodinium polykrikoides*, which represented respectively only 2.2, 1.6, and 0.2 % of the total Bay cysts. In a similar fashion, the taxa within the "*Gonyaulax*"complex" and the *Protoperidinium* spp. group had low representation compared to other cysts in the tributaries, being generally found in the lower segments of these rivers. The dinoflagellate cysts also included an "unidentified" category. These cysts were in different degrees of decomposition, and lacked adequate morphological features for complete identification. Additional taxa may be represented in this cyst category, but were not recognizable.

DISCUSSION

Major differences were noted in the representation of dominant dinoflagellate cysts in sediment from the three rivers compared to cysts dominant in the Chesapeake Bay sediment. The most abundant river cysts were those produced by the major bloom producing species in these waters. Their cysts dominated the surface sediment (upper 2 cm) from these rivers with higher concentrations in the lower segments of these rivers, and included *Heterocapsa triquetra*, *Cochlodinium polykrikoides*, *Scrippsiella trochoidea*, and *Polykrikos kofoidii.* Their annual blooms regularly produced cysts that entered the sediment of these rivers resulting in "seed" beds for the reoccurring generations of these taxa in the water column. The sediment analysis indicated the importance of these river regions as reservoirs for dinoflagellate cysts, and the origin of potential bloom producing species in the water column.

In contrast, the Chesapeake Bay sediment cysts were derived mainly from neritic and oceanic taxa. Their origin in the Bay would come mainly from sub-pycnocline waters entering from the Atlantic coastal shelf. Tyler and Seliger (1978) and Tyler et al. (1982) have described dinoflagellates being transported in this manner along the main stem of the Bay and the Potomac River. However, there was only a moderate presence of cysts common to a neritic or oceanic origin in the lower segments of these rivers, and a general lack of the dominant river species in the Bay sediments. Even though blooms of the river species may extend into Chesapeake Bay, their cysts were not abundant in the Bay sediment. The cyst producing taxa included *Cochlodinium polykrikoides* and *Pyrodinium bahamense* v. *compressum* Wall and Dale as potential toxin producing species. Of these, *C. polykrikoides* has produced extensive and long lasting blooms in the York and James rivers, in addition to their associated tributaries (Marshall et al. 2008).

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these rivers and the Chesapeake Bay. D.W. Seaborn processed and analyzed the sediment samples, with H.G. Marshall assisting in the organization and preparation of the manuscript.

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Induction of Winter Breeding in Small Mammals by 6-MBOA

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ABSTRACT

A plant-derived cyclic carbamate, 6-methoxybenzoxazolinone (6-MBOA), is known to initiate reproductive activity in *Microtus montanus.* We studied overwintering populations of four other rodent species, and observed increased reproduction in experimental populations of two herbivorous species, *Microtus pennsylvanicus* and *Sigmodon hispidus,* but not in two omnivorous species, *Oryzomys palustris* and *Mus musculus.* These results suggest that low concentrations of 6-MBOA may trigger seasonal breeding primarily in herbivorous small mammals.

INTRODUCTION

Many species of herbivorous mammals appear to initiate breeding after ingesting green vegetation (e.g., Batzli and Pitelka 1971, Reynolds and Turkowski 1972, Van De Graaf and Balda 1973, Negus and Berger 1977). Later, Berger et al. (1981) demonstrated that reproduction in one small herbivore, *Microtus montanus,* the montane vole, is cued by 6-methoxybenzoxazolinone (6-MBOA) and/or its precursor 2, 4-Dihydroxy-7- methoxy-2H-1,4-benzoxasin-3-(4H)-one (DIMBOA), which is common in seedlings and in rapidly growing plant parts (Sanders et al. 1981). Berger et al. (1981) suggested that 6-MBOA might elicit reproductive responses in many mammals because its site of action is high in the neuroendocrine system. We sought to examine the generality of the effects of 6-MBOA in initiating breeding among seasonally reproducing mammals by using a phylogenetically diverse group of four rodents studied during the winter months, the usual period of non-breeding for many rodents. *Microtus pennsylvanicus* (meadow vole) and *Sigmodon hispidus* (hispid cotton rat), which are almost exclusively herbivorous (Zimmerman 1965, Fleharty and Olson 1969), responded to the stimulation of 6-MBOA by increasing their levels of reproduction in midwinter, but the omnivorous *Oryzomys palustris* (marsh rice rat) and *Mus musculus* (house mouse) did not respond (Negus et al. 1961, Rose and McGurk 2006, Miller and Webb 2001).

STUDY AREA AND METHODS

This experimental field study was conducted during the winter months of December to February. We set four 0.25-ha live-trapping grids at each of two sites in southeastern Virginia. At one site, with oldfields dominated by the perennial grass Fescue (*Festuca* spp.), pairs of grids were separated by a highway interchange in the Bowers Hill section

of Chesapeake, Virginia. The other study site was located in non-tidal marshes on Fisherman Island, a small barrier island 40 km north, at the entrance to the Chesapeake Bay, where American beach grass (*Ammophila breviligulata*) and wax myrtle (*Myrica cerifera*) were dominant. The tidal creek that separated the pairs of grids isolated at least the grid populations of house mice. At each location the Fitch live traps on two 5 by 5 grids, with 12.5-m intervals, received supplemental food while the other two grids received sham-treated food. (In all respects, the experimental protocol followed Berger et al. [1981].) The food was in the form of rolled oats bait coated with 6-MBOA dissolved in ether and ethanol (4:1) at a concentration of 40 μg 6-MBOA g^{-1} oats (treatment) or solvent only (sham-treated control). Solvent was allowed to evaporate. The 6-MBOA- or sham-treated oats were placed inside the locked-open traps (and replenished every third day) between periods of active trapping, making the traps into feeding stations. Trapping was conducted during weeks 1, 3, and 5. Each rodent was marked with a numbered ear tag, and externally evaluated for sex and reproductive condition before its release. Traps were locked open between trapping periods, permitting free access to the bait. After 5 weeks, animals were live trapped and removed to the laboratory for necropsy. To determine baseline levels of winter breeding activity, samples of rodents were collected in habitat contiguous with the trapping grids at the start of the study in late December. At the end of the experiment, animals were removed from the trapping grids, euthanized, and necropsied for signs of reproductive activity. Testes were weighed to the nearest mg, and the cauda epididymides were examined for the convolutions that indicate the presence of mature sperm (Jameson 1950). Uteri were examined for visible signs of pregnancy, ovaries for evidence of ovulation (corpora lutea), and reproductive tracts were weighed to the nearest mg. Animals were necropsied without knowledge of whether they had been removed from control or experimental grids until all necropsies had been completed. Then, an animal's treatment (6-MBOA or sham) was determined by examining its field tag number.

Tests for differences ($P < 0.05$) in body and gonadal weights of pretrial, control, and treatment animals were made using one-way analysis of variance (ANOVA), and identification of differing group means was made by using Least Significance Difference tests. Student's *t*- and Chi-square tests also were used.

RESULTS

Only *Microtus* showed evidence of reproduction in late December at the start of the study (Table 1), with one of eight females being pregnant and one-third of males judged to be fertile. The other three species showed the typical pattern of temperate rodents in the wintertime: no embryos or corpora lutea in females and regressed testes and looped epididymides in males.

The 6-MBOA appeared to have had a variable effect on the four rodent species. Reproductive organ weights were significantly larger in both sexes of *M. pennsylvanicus* and in male *Sigmodon* (Table 1). This pattern was consistent with other evidence of reproductive activity. For example, a significantly greater proportion of the adult female *Microtus* was pregnant on the experimental grids (10/22) than on the control grids (3/20, $X^2 = 4.55$, $P < 0.05$) and the mean weights of litters were significantly heavier (4761.6 ± 1162.77 SE mg, treatment; 896.7 ± 564.07 SE mg, control; $t = 2.92$, $P < 0.025$), suggesting they had become pregnant earlier and were

TABLE 1. Effect of 6-MBOA on standardized reproductive organ weights (♀ = ovary + uteri weight/body weight (mg/g); (♂ = paired testes weight/body weight (mg/g) of four species of rodents (Treatment) compared to those receiving sham-treated supplemental food (Control) and to baseline reproduction at the start of the experiment (Pretrial). Measurements are given as mean weight ± standard error of the mean. Pregnant females were excluded from the analysis of organ/body weight ratios. Percent breeding for females refers to the percent pregnant and for males to the percent with convoluted epididymides. For *Mus*, B and F refer to the Bowers Hill (B) and Fisherman (F) study sites.

Species	N	Pretrial	% Breeding	N	Control	% Breeding	N	Treatment	%Breeding
Mus musculus (B) ♀	27	0.57 ± 0.08	0.0	10	1.45± 0.29	0.0	3	3.89± 1.25	0.0
Mus musculus (F) ♀	33	1.19 ± 0.21	0.0	25	2.92± 0.38	12.0	18	2.10± 0.27	0.0
Microtus pennsylvanicus ♀	8	1.08 ± 0.24	12.5	15	2.79± 0.46	15.0	12	4.66± 0.56	45.5
Sigmodon hispidus ♀	6	0.47 ± 0.12	0.0	4	0.72±0.35	0.0	16	0.74±0.01	0.0
Oryzomys palustris♀	2	0.52 ± 0.04	0.0	7	0.98±0.20	0.0	5	1.16±0.22	0.0
Mus musculus (B) ♂	25	1.61 ± 0.24	0.0	16	4.07± 0.29	60.0	7	4.20± 0.31	57.1
Mus musculus (F) ♂	35	2.75 ± 0.08	4.0	29	4.63± 0.22	62.0	18	4.53± 0.20	58.8
Microtus pennsylvanicus ♂	9	9.35 ± 1.38	33.3	35	14.42± 2.70	37.5	21	19.40± 0.70	65.0
Sigmodon hispidus ♂	3	1.22 ± 0.69	0.0	7	2.93± 0.73	0.0	14	5.22± 0.45	42.9
Oryzomys palustris ♂	14	1.22 ± 0.22	0.0	4	5.29± 0.58	0.0	5	5.90± 0.52	0.0

nearer term. There were no significant differences in the numbers of embryos per female (3.1 ± 0.28 SE, treatment; 2.7 ± 0.88 SE, control). A greater proportion of male *Microtus* exhibited convoluted cauda epididymides on the experimental grids than on the control grids ($X^2 = 3.93$, $P < 0.05$). Male *Sigmodon* showed a similar pattern ($X^2 = 4.20$, $P < 0.05$). No differences in breeding activity between animals on control and experimental grids were noted for the remaining groups (*Mus, Oryzomys,* and female *Sigmodon*; Table 1).

DISCUSSION

Our results indicated that 6-MBOA stimulates breeding in two species of small mammals in the grassland habitat. As with montane voles (Berger et al. 1981), meadow voles of both sexes showed a rapid reproductive response following exposure to 6-MBOA. Gonadal weights of male and female meadow voles, under stimulation of 6-MBOA, increased significantly compared to controls and pregnancy rates were significantly higher too. Such synchronous responses by both sexes may be an adaptation of microtine rodents to quickly exploit food resources for secondary production when they become available. Using one male and two female reproductive indices in *Microtus ochrogaster,* the prairie vole, from eastern Kansas, Rose and Gaines (1978) demonstrated synchrony of males and females in their breeding activity: adjusted testes weights, pregnancy rates, and litter sizes showed significant seasonal concordance over a population cycle. Although other studies of reproduction in *Microtus* (Keller and Krebs 1970, Negus et al.1977, among others) have sought to identify the length of the breeding season, most have not examined the differences between males and females in the onset or cessation of breeding. Nevertheless, it is clear from reproductive studies that *Microtus* sometimes continues breeding throughout the winter months, even in arctic locations where long dark winters prevail (Krebs and Myers 1974). Whether 6-MBOA and related plant compounds are involved in the breeding synchrony of the sexes in initiating winter breeding at northern latitudes remains to be determined, but 6-MBOA did enhance the low level of winter breeding among the meadow voles in our study by significantly increasing the proportions of breeding males and females compared to contemporaneous animals on control grids.

By contrast, in a winter study conducted near Vancouver, Canada, Korn and Taitt (1987) found that only female *Microtus townsendii* (Townsend's vole) responded to the same 6-MBOA treatment that we used (Berger et al. 1981) in our study. Although males on the experimental grid became significantly heavier (but did not have longer body lengths) than control males, all males had similar proportions of descended testes, a valid measure of fertility (McCravy and Rose, 1992). Korn and Taitt (1987) speculate that males respond more strongly to photoperiod and females to new plant growth as the determining factors in the reproductive cycle of Townsend's vole.

Except for control male *Sigmodon*, pretrial animals had significantly lower gonadal weights than either treatment or control animals that were collected five weeks later (Table 1), a pattern also observed in *M. montanus* (Berger et al. 1981). This result might be due either to the effects of providing supplemental food or may represent the seasonal pattern of gonadal changes leading up to regaining fertility and the resumption of breeding. The latter possibility seems more likely because control and treatment animals were not significantly heavier or longer than pretrial animals, as would be expected if supplemental food *per se* were a significant factor in the weight differences.

Several authors have suggested that green vegetation or their extracts put males in a state of reproductive readiness: Negus and Pinter 1966, Berger and Negus 1974 for *Microtus montanus*; Chew and Butterworth 1964, and Van De Graaf and Balda 1973 for *Dipodomys merriami*, a desert kangaroo rat. The latter authors evaluated levels of reproduction of *D. merriami* from two desert areas, one receiving three times more rainfall in autumn and winter than the other. By mid-February, the animals on the wetter area were significantly heavier, and were breeding at high levels, 92% for females and 95% for males, using reproductive features determined by necropsy, whereas kangaroo rats from the drier site showed 7% levels of reproduction (Van De Graaf and Balda 1973). Later, McClenaghan (1987) administered a range of concentrations of 6-MBOA to 40 wild-caught female *D. merriami* in the laboratory. Because neither ovaries nor uteri increased in weight following injections of 6-MBOA, McClenaghan suggested that factors other than 6-MBOA were responsible for the reproductive differences observed by Van De Graaf and Balda (1973) on *D. merriami*. However, in a field study of another desert rodent, *Gerbillus harwoodii*, in which 6-MBOA was administered according to Berger et al. (1981), both sexes increased gonadal weights on experimental grids but only testes weights were significantly greater than for control males (Alibhai, 1986). Thus, desert rodents tested with 6-MBOA also show a variable response similar to those of grassland small mammals.

In many mammals (Sadleir 1969), including *Sigmodon* (Glass and Slade 1980a, 1980b, McClenaghan and Gaines 1978, Rose and Mitchell 1990, Bergstrom and Rose 2004), males are reproductively active two to four weeks before and after the reproductive seasons of females. For these species, two possible stimuli could induce females to become reproductively active: the presence of mature males or their pheromones are required to trigger neuroendocrine pathways in females, or males are necessary only after food, weather, and daylength factors bring females into the proper physiological state for reproduction. Experimental evidence indicates that for some species at least, male rodents influence the maturation rates of females, often through chemical signals in urine (e.g., Vandenbergh 1967, 1969, 1976, Lombardi and Vandenbergh 1977, Drickamer 1979). Although these studies have evaluated the effects of adult males on the rates of maturation of juvenile and subadult females, the same rules probably apply to stimulating gonadal recrudescence in adult females that had been reproductively quiescent, e.g., during the winter months. Thus, it seems likely that in the species in which males mature first the presence of reproductively ready males may be required to stimulate females to initiate the ovarian cycle and become reproductively mature. In *Sigmodon hispidus*, the males have a large perineal gland that recrudesces and regresses in synchrony with the seminal vesicles, both apparently being regulated by androgen levels produced by the testes (Rose and Winchell, unpublished). Although the role of the perineal gland is unknown, its cyclicity with both testes and seminal vesicles suggests that the perineal gland is an apocrine gland, secreting pheromones placed by the male's urine into the environment, and signaling the presence of reproductive males to females.

Because male cotton rats mature about one month earlier than females in Virginia (Rose and Mitchell 1990, Bergstrom and Rose 2004), the differential responses of male and female *Sigmodon* to 6-MBOA are not so difficult to explain. Males showed a clear response, both in testes weight/body weight ratios and in having sperm in the cauda epididymides. Whether the mechanism to stimulate females to breed comes directly

through food (but requiring a different dose or duration of 6-MBOA stimulation than for males) or indirectly through an association with reproductively mature males, we interpret *Sigmodon* to be a species that responds to the stimulation of 6-MBOA.

Due to their mixed diets, the initiation of breeding in omnivores may be less closely linked to primary production (and to such cues as 6-MBOA) than in herbivores. Thus, omnivorous species such as *Mus* and *Oryzomys* might be expected to rely less on chemical cues present in new growth of vegetation and more on other environmental factors for initiating reproduction. It should be kept in mind, however, that because only a single concentration of 6-MBOA was provided during our field study, the reasons for the failure of these species to respond remain unclear. Studies under controlled laboratory conditions will be required to determine whether there is a real dichotomy between herbivorous and omnivorous small mammals in their responses to 6-MBOA.

In summary, low concentrations of the plant-derived hormone, 6-MBOA, initiated or enhanced breeding in winter populations of herbivorous *Microtus* and *Sigmodon* but not in the omnivorous-to-carnivorous *Mus* and *Oryzomys* living in the same grassland communities. When spring arrives earlier than normal in cold environments, or in geographic locations in which winters are relatively mild, cues from newly growing vegetation may be superior to photoperiod in permitting a population to expand quickly and by exploiting the available resources. If the timing of the breeding season is a life-history strategy (Stearns 1976), natural selection should favor the retention of such adaptations.

ACKNOWLEDGMENTS

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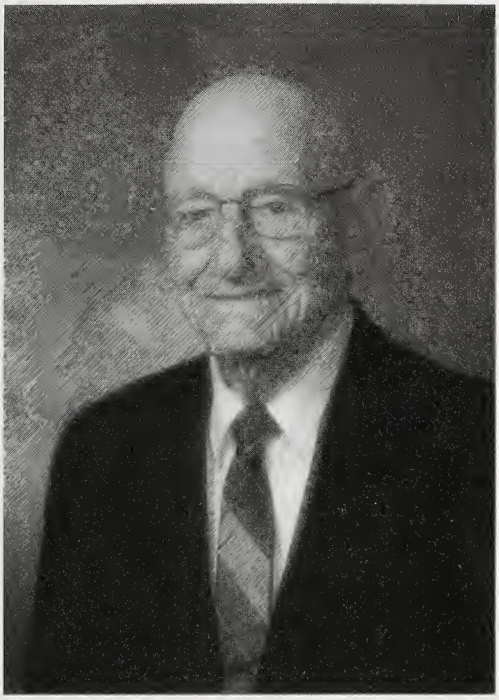

JACKSON JOHNSON TAYLOR
1918 – 2008

Past Academy president and Fellow, Jackson Johnson Taylor, 89, of Mechanicsville, Va., died Thursday, July 31, 2008. He was born at "Shrub Hill," his family's farm in Winnabow, N.C., on November 20, 1918, and was the son of Edwin Wellington Taylor and Alice Jackson Johnson Taylor. He received his B.S. degree in physics from the University of Richmond in 1942 and in 1948, he completed his M.S. degree at Cornell University. He began his 38-year career as professor of physics (1948-1986) at the University of Richmond, serving as chairman of the physics department for 21 years. All of us remember him as an inspired and outstanding teacher. He was named a UR Distinguished Educator in 1976. In 1989, the Jackson J. Taylor Best Senior Seminar in Physics Award was established in honor of Professor Taylor, to recognize the student judged by the faculty of the Department of Physics to have presented the best senior seminar.

During WWII, he served aboard the "Duxbury Bay" as Lieutenant JG, USNR, Fleet Air Wing One, receiving two Battle Stars in the Okinawa campaign.

Professor Taylor was a long time member of the Virginia Academy of Science, serving as President from 1962 to 1963 and was elected Fellow in 1979. He also was a member of the American Association of Physics Teachers (Chairman, Va. Area, President Chesapeake Section, National Council Representative), Sigma Pi Sigma (physics), Omicron Delta Kappa (leadership) and Phi Gamma Delta.

A lifelong Presbyterian, Professor Taylor served as Elder and Clerk of Session at

Tuckahoe Presbyterian Church, as Elder at Bon Air Presbyterian Church, as president of the Richmond Area Council of Presbyterian Churches and on various presbytery and synod committees. Most recently, he was a member of Fairfield Presbyterian Church.

Since 2002, Professor Taylor was an active member of the Covenant Woods community in Mechanicsville, serving on committees and using his passion for photography to enrich the lives of Covenant Woods residents by helping many residents develop their photographic skills and encouraging them to display their photos along with his own wonderful photos. He was an award-winning member of the Lee Artists Association. Professor Taylor is survived by his wife, Elizabeth Beaman Taylor.

Partially adapted from an obituary Published in the Richmond Times-Dispatch on 8/2/2008.

Virginia Academy of Science, Executive Committee Meeting
Saturday, March 29, 2008
Science Museum of Virginia
Presiding: Werner Wieland

Call to Order: The meeting was called to order at 9:30 am

Approval of Minutes: The minutes of November 18, 2007 Executive Committee recommended for approval with changes

Local Arrangements Committee:

Based on the conference site visit held on March 28, 2008 Dr. Whitney, chair of the local arrangements committee reported the

- The arrangements for meal and room assignments are finalized.
- Though all equipments are continue to be tracked down there does not seem to be any problem.
- Working on confirmation of availability of the tech support
- A separate telephone number be available for the conference
- Dr. Harvey will deliver Jeffers Memorial Lecture on Tuesday night.
- Dr. Roger Crouch, astronaut from NASA will speak on Wednesday evening for VJAS at the Virginia Air and Space Center
- Sidney S. Negus Memorial Lecture will be deliver by Dr. Pat McCormick on Thursday
- Prof. Willis is working on the program book
- Final version of drafts of various forms, including electron payment form is underway
- Few details are to be worked out about hotel accommodations

Jerry asked for the names of any guests who would make remarks during the meetings so that their names can be included in the program book, or a separate table can be reserved for them.

Officers Report:

President:

- Reiterated the items from the report by chair of the local arrangement committee about his conference site visit on March 28, 2008
- Issue of paper presentation by members/non-members under "statistics" category was discussed

President Elect:

- Working on few missing information in the academy directory including dates

- Reported that NAAS has approved a resolution on State Science & Technology Policy February 18, 2008 (Appendix A)

- Several suggestions were made to generate interest for increasing the number of academy members including organizing a symposium in 2009

Vice President:

- Annual Meeting Program book is almost complete and will send to some members for review
- Needs clarification on few items from VJAS director Mrs. Booth and chair, local arrangement committee Dr. Whitney before finalizing the program book
- Sessions on Geography and Geology not needed and material science is "Astronomy, Mathematics and Physics
- Because of low numbers multiple sessions on Medical Science is cropped of

Secretary: Minutes from last meeting was submitted for approval

Treasurer: No report

Executive Officer:
Reported that:

- the tax papers are ready to be filed
- the funds have been transferred to funds for the future
- the meeting with new director of Science Museum was cordial and we are well supported by the museum, a copy of history of the Academy was presented to the new director
- retreat reservation has been made for Sept 19, 2008 for 15-20 people. Reporting Friday evening and retreat finishes Saturday afternoon. Jim will put a tight agenda for retreat
- received one paper for Shelton Horsley Research Award which has been forwarded to the Chair, research committee Dr. Mohamed
- UG research symposium held in Fall has helped recruit students and faculty (?)

Following hand-outs, including reports from Chair, Trust Committee Ms. Falls were distributed:

- Summary of Receipts, Disbursements and Year-end Balances for 2007
- Income/Expense Comparison by Category – 2006 (1-1-06 through 12-31-07)
- Historical account balance as of 12-31-2007 from American Funds
- Virginia Academy of Science Endowment Funds (12-31-07)
- Income/Expense Comparison by Category YTD-2 (1-1-2007 through 3-25-2008)

- VJAS Endowment – Accounting for Awards held in Endowment Mar 2008
- Senior Academy Awards and Funds March 2008

Better breakup for Trust category was requested

VJAS Director:

- Reported the numbers of papers received are less than previous year
- Few sections have to be merged
- Requested to encourage faculty to sign up for judges

Old Business:

Future Meetings sites:

- 2008 – Hampton University – site visit completed on March 28, 2008
- 2009 – VCU - Confirmed
- 2010 – JMU – No paper work is done yet; not to have meeting on memorial day weekend; during Wednesday – Friday
- 2011 – Radford University
- 2012 – Christopher Newport University
- Old Dominion University can be approached

New Business:

Following slate of nominations for offices is approved:

Jim Martin: President
Darcy Mays: President-Elect
Arun Verma: Vice-President
Michael Renfro: Secretary and
Rodney J. Dyer: Treasurer

Adjournment:

Meeting adjourned at 11:00 am

2008 COUNCIL MEETING
Saturday March 29, 2008
Science Museum of Virginia

Call to Order: The Academy Council Meeting called to order at 11:12 AM
Approval of Minutes: A draft of minutes of Council meeting held on November 18, 2007 was presented for approval. The minutes were approved with the following Corrections:

Under Reports –

- Awards: "One nomination reported" should read as "One nomination for fellow has been received"
- "Constitution & Bye-laws – Gerry Taylor
    - Minor changes proposed (Appendix B – Constitution & Byelaws Committee Report to Council)*. It is to be done during Spring 2008 meeting". should read as

  "Constitution & By-laws – Jerry Taylor
    - Report submitted clarifying issues (Appendix B – Constitution & Bylaws Committee Report to Council)*"
- Environment:
    - "Mary Washington University" should read as "University of Mary Washington."
- Fellows: the only minute should read as
    - "Dr. Kenneth R. Lawless donated about 3000 pictures. Dr. Lawless, who was an academy fellow died in August 2007. He was 85."
- Fund Raising: the minute should read as
    - "Requested advise from the Council for exploring a plan for fund-raising campaign with 90th anniversary celebration."
- Under New Business: the third bullet should read as
    - "Names proposed for Research Committee – Joe D. Rudmin, Allison Baski, Lisa Alty, William Starnes"

Financial Report:

- Jerry presented the financial report and pointed that the income from the annual meeting held at James Madison University were down because of two reasons: Poor attendance and per person charge
- He indicated that to make the accounting simpler trust description has been changed
- Nothing significant change from previous year

Annual Meeting update:

- Dr. Harvey will deliver Jeffers Memorial Lecture on Tuesday night. The

details has to be sent to Jim O'Brian for newsletter.

Reports:

- Archives: Jeff Zadeh: Nothing to report
- Awards: Carolyn Conway
  - The committee consisting of Jim O'Brien, Victor Townsend and Andrew Dolby, nominated Dr. David G. Elmes of Washington and Lee University for the Academic Fellow.
- Constitution & By-laws: Jerry Taylor
  - Elsa Q. Falls, Chair Trust Committee serves as representative to Finance & Endowment committee
  - Arthur W. Burke, Jr. is chair of Finance & Endowment Committee
  - Two members are to be nominated for terms ending the following years
- Environment: Michael L. Bass
  - Reported that he has represented Academy at various conferences
- Fellows
  - Jim reported Rae could not be there and will not be there at the May's meeting either
- Finance & Endowment: Arthur W. Burke, Jr.
  - Expressed concern about reduced income
  - Reminded academy to stop spending from Trust funds
  - Reduction of fees (?) from 10% - to 5-7% was discussed as other institutions have around 4-5%
  - Seek more outside funding
  - Raising the meeting fees was discussed
- Flora of Virginia: Marion Lobstein
  - Updated on the *Flora of Virginia* Project
- Fund Raising: Jim O'Brien
  - Bruner Family
  - Approach Private Philanthropies using slides and material
  - TCC is not listed as a member institution
  - Various issues were presents at AAAS
  - Shared the NAAS recent resolution
- VJAS: Susan Booth
  - Reported the numbers of papers received are less than previous year

- Few sections have to be merged
- Requested to encourage faculty to sign up for judges

- Long Range Planning – Werner Wieland
  - Next annual meeting at VCU is on track
  - Chanco retreat September 19-20, 08
  - ODU contact person Paul Homsher
- Membership – Richard Groover
  - Report on Membership submitted in the last council meeting

Nominations –

- Slate of nomination recommended by Executive Committee was presented and approved
- Darcy Mays is replacing Bob Willis for president-elect

- Publication – Jim Martin
  - The last issue of 2007 is two-weeks away from publication
- Research
  - received one paper for Shelton Horsley Research Award which has been forwarded to the Chair, research committee Dr. Mohamed
  - He is still willing to involve with academy work
- Science Advisory – Alan Griffith
  - No report
- Trust – Elsa Falls

Following hand-outs, including reports from Chair, Trust Committee Ms. Falls were distributed:

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- VJAS Endowment – Accounting for Awards held in Endowment Mar 2008

- Senior Academy Awards and Funds March 2008

- VRSN – David Hagan
  - No Report
- Discussion about motion for nomination of Dr. David Elm as academy fellow

Section Reports:

- Aeronautical & Aerospace Sciences -No Report
- Agricultural, Forestry, and Aquaculture - No Report
- Archeology - No Report
- Astronomy, Math, Physics, with Material Science - No Report
- Biology with Microbiology - No Report
- Biomedical & General Engineering - No Report
- Botany: Michael H. Renfroe
  - Has full schedule
- Chemistry: Tomas C. DeVore
  - Planning to open Dr. Urasa's symposium to all the attendees
- Environmental Science: Michael L. Bass
  - Among presentations received most of them are posters and two are papers
- Molecular Biology: Now included in "Biology with Microbiology"
- Natural History & Biodiversity: Leeanna Pletcher
  - Werner reported that Has a full program
- Psychology: Perry M. Duncan
  - Full morning session. Only one-third of what we had in past.
- Statistics

  No Report

Old Business

- No Old Business

New Business

- No new business

Adjournment: The council adjourned at 1:05 PM.

VAS CHANCO Conference
September 19, 2008

The meeting was called to order at 7 pm. Jim Martin welcomed the conferees.

Jim Martin announced that he is retiring and Lisa Martin is resigning around the end of June so that they can enjoy their retirement plans. Jerry Bass plans to retire as well in the near future

A job description was prepared for the VAS Administrative Assistant, Business Manager of the Journal, Web Master, and Director of VJAS. Jim will continue for a time as Business Manager of the Journal and may or may not continue as Web Master.

We need to develop a plan to bring someone in at the beginning of March to learn the procedures and operations of the Academy before it gets very busy with the Academy meetings. Preference would be for someone living in the Richmond area so that they can work in the Academy office and for someone who would be in the position for several years so that they could gain experience and maintain some continuity in the position.

The question was raised about having someone working part time for the Science Museum and part time for the VAS. It was concluded that a split position was not desirable.

Another suggestion was made that the two positions of Administrative Assistant and Executive Officer could be combined into a full-time position. It was pointed out that two signatures are required for writing checks and that two people provide a checks-and-balance system for financial oversight.

It was pointed out that both positions would be well served by retired individuals who needed only a supplemental income and could do some of the work at home.

Membership is declining and faculty members are attending national meetings more than state meetings and funding of these positions may be an issue in future years. The Fund for the Future has not matured and was intended to provide funds in future years, but might have to be tapped earlier.

A call was made for nominations for the positions or to develop a plan as to how to attract applicants for the positions. It was suggested that we could advertise the positions.

Office team member compatibility is important to the smooth functioning of the office. A strong consideration is to have someone with familiarity of the academy to be able to answer outside inquiries.

It was suggested that the role of Administrative Assistant would look to the Executive Officer as the in-line boss. Therefore, the timing of hiring for both positions is critical. The Executive Officer should be hired first as the Administrative Assistant will have to work extensively with the Executive Officer. There has to be a close working relationship between the two positions with open communication.

It was suggested that a committee be formed with two or three members to

actively recruit for the Executive Officer position. It was suggested that we focus on people who have a history with the Academy and who have knowledge of, and love for the organization. It could be announced within the Academy publications.

It was noted that the workload of the Administrative Assistant varies greatly depending upon the time of the year. It varies from part time to more than full-time depending upon the season. The hours are flexible, however, for most of the year.

An inquiry was made as to the vitality of the status of the Journal. Journal distribution and readership probably peaked in early 1990s. Requests are frequently made for articles from back to the 1950s and 1960s. It was observed that journals often disappear once they become web-based and some have gone back to paper. It is important to keep the journal in paper form, but have articles accessible through the internet. We could be more aggressive in soliciting papers. Production costs are down compared to the past while maintaining a quality product. It is important to keep high quality paper for bound journals in the libraries.

Fund for the Future monies are not coming from meetings. Meeting revenues are declining because of rising costs for services from host institutions. Meeting costs are becoming too prohibitive to place excess revenues into the trust fund. We need to get increased revenue from the meetings. However, if we increase dues and increase meeting fees it will probably hurt membership and future revenue prospects.

The question was raised as to whether we should we have one committee to solicit for both positions or should be have one committee for each position. This will be revisited tomorrow.

The question was raised as to what recommendation we should make to the NAAS regarding the Dallas Cock Memorial Award. The options are to make it an essay-based student award, or honoring a professional educator's contribution to the AJAS.

Virginia Scientist will only have three issues this year.

Jim O'Brien mentioned that we would be working toward a Centennial Fund Raising drive and provided a sample fundraising letter. He also mentioned that fundraising needs to be an annual event and we should initiate annual fundraising activities. He suggested that the activities should be coordinated out of the central office. We could focus on corporations, preferred zip codes, state general assembly members, and other groups to raise our visibility and try to generate funds.

The meeting was adjourned at 9:05 pm.

VAS CHANCO Conference
September 20, 2008

The meeting was called to order at 9 am.

Jim mentioned that items 1-6 on the job description of the Journal Business Manager could be covered by the Executive Officer. Items 7-10 and 2h could be transferred to the duties of the Administrative Assistant.

Deliberations resumed about the staffing of the Journal Business Manager, Executive Officer and Administrative Assistant positions. We need to develop a plan to have overlapping terms to train incoming individuals.

It was suggested that advertising the positions might attract the attention of someone who has an interest, but of whom we are unaware. We also need to talk to other members within the academy who might have an interest. The individuals should be a member of the academy and live within a 25 mile radius of Richmond.

Art Burke made a motion that the President appoint two separate committees of three members or less, with the incumbent member being an ex-officio member of the committee. Motion was seconded by Ray. Discussion ensued.

It is strongly preferred that the Executive Officer be found from within the Academy membership. The Administrative Assistant might have to be advertised more widely. Finding someone for the Executive Officer position first would be preferable.

The motion was unanimously approved.

Jim Martin appointed Jerry Bass, Elsa Falls, and Werner Weiland to the Executive Officer search committee. Werner is the committee chair. Jim is an ex-officio member by virtue of the presidency.

Jim Martin appointed Lisa Martin, Art Burke, and Carolyn Conway to the Administrative Assistant search committee. Art is the committee chair. Jim is an ex-officio member by virtue of the presidency.

As a target date, we should try to find candidates that can start around the first of the year and receive training prior to the meeting. With new individuals, the chain of command for authoritative decisions and evaluations should be made clear. It was suggested that a Office Policy be developed to cover these items.

It was noted that someone from outside the organization with financial experience might be desirable.

Guidelines were provided to the committees. Members will be screened within a geographic radius to prepare a list of potential candidates. Beyond that, the positions may be advertised to the entire membership. It is recognized that we are on a short time line and need to have initial candidates in mind by November so that we could potentially have candidates in the positions by around the first of the next calendar year.

The committee needs to determine when the financial compensation starts. The candidates should observe operations before they are hired.

It was suggested that an Operations Manual be developed for each position to make transitions easier in the future.

Jim will provide each committee with job descriptions and a list of members.

Elsa Falls reported regarding the Trust Fund that as of yesterday, compared to end of second quarter, the trust fund was at $965,964. Money to run the academy has amounted to $60,000 for the year. More money is going out than is coming in.

The only outstanding revenue, besides fall dues, is about $17,000 from the Hampton academy meeting. We are living on principle and may need to take some executive action on budgeting for the coming year. It was suggested that perhaps we suspend travel to the AAAS meeting for one year. Alternatively, the student's family or school could cover more of the expenses. For example, we could pay the registration, but not pay the air fare or lodging. We also could restrict the number of students we fund and not pay for sponsors.

We need to have a clear policy for funding with line item listing of expenses.

Art made a motion to authorize the Junior Academy to attend the next AJAS national meeting, and the budget for the trip will be set by the academy. Motion was seconded. Discussion ensued. It was suggested that since the meeting attendance is part of the award structure for the student, someone from the Junior Academy should be engaged in fund raising to support travel. It was also suggested that students be supported, but not support the sponsors financially. The motion was defeated 3 to 9. It was pointed out that the mechanism is in place through the Finance Committee to control the expenditures.

It was recommended that the President in writing let the academy know that the annual budget must not be exceeded and may need to be reduced in the coming year. The 2009 budget needs to be closely scrutinized. Because of designated accounts in the Trust Fund, the operating base is constrained. The challenge for the academy in the future is how to increase the revenue stream. The Fund for the Future was developed to fund the Junior Academy Director, and ultimately, the Academy Director as well. A decision needs to be made as to when to draw on that account. The academy needs to operate on the revenue generated from the annual meeting and the exhibitor's fees.

If VCU will allow exhibitors to be placed in a prime location with traffic flow, Ray Carpenter has volunteered to solicit vendors, publishers, and college recruiters to attend the meeting. Don Whitney submitted a report on the finances from the Hampton University annual meeting. The meeting generated just over $17,000.

It was suggested that the Finance Committee meet before the end of the year to begin looking at the long-range issues as well as the forthcoming annual budget.

The meeting was adjourned at 11:00 am so that search committees could convene for an organizational meeting.

VIRGINIA ACADEMY OF SCIENCE

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THE VIRGINIA JOURNAL OF SCIENCE

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VIRGINIA JOURNAL OF SCIENCE

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Low-Density Rodent Communities in Eastern Virginia

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ABSTRACT

Two communities of small mammals were live trapped every other week for 15 months in linear oldfield habitat bordered by forested swampland in eastern Virginia. All nine species of the rodent community were present, mostly in low numbers and often intermittently. All species were characterized by high transiency, with a minority of marked animals becoming resident. Despite high trappability, all but two species in these communities had extremely low densities, suggesting that most species could not sustain populations via in situ reproduction.

INTRODUCTION

Populations of small mammals usually are studied only at locations where favorable habitat makes the production of moderate-to-high densities a probability in most years, yielding many observations for the amount of expended field work and making statistical testing possible. Similarly, communities of small mammals are studied in the primary habitat of that group, such as grassland, forest, or desert. When a linear habitat of one type passes through a matrix of another habitat type, such as when a powerline, with its open habitat beneath, passes through a forest, the possibilities of a broader, more speciose community of small mammals can be realized.

We studied two locations in the Dismal Swamp of eastern Virginia, with the goal of conducting a population study of the Dismal Swamp subspecies of *Synaptomys cooperi helaletes*, the southern bog lemming. Earlier field studies using pitfall traps (Rose 1981) had revealed its presence, after speculation by several investigators (Handley 1979, Meanley 1973, Taylor 1974), that this arvicoline rodent might be extinct because it had not been found since the U. S. Biological Surveys conducted in the Dismal Swamp in the 1890s (Merriam 1896).

The objectives of our study were to:

1. conduct a population study of the southern bog lemming,
2. describe the dynamics of small mammal communities in two clearings of the Dismal Swamp, a forested swampland, and
3. evaluate the spatial distributions of small mammals based on the vegetational structure of the habitat.

METHODS

Our study was conducted in the 40 m wide opening under a 110 kv powerline in the

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northwest corner of the Great Dismal Swamp National Wildlife Refuge, where the first specimens of *Synaptomys cooperi* were collected in the 20th Century (Rose 1981). The vegetation under the powerline is maintained at an early successional stage by 3-5 y mowings by Dominion Virginia Power. One study grid was placed in an area dominated by American cane (*Arundinaria gigantea*), the other in an area with a thick herbaceous layer of panic grasses (*Panicum* spp.) and soft rushes (*Juncus* spp.). Both grids had numerous scattered seedlings and saplings of red maple (*Acer rubrum*), sweet gum (*Liquidambar styraciflua*) and loblolly pine (*Pinus taeda*).

Our 15 mo of trapping began in December and ended in February of the second year. Grid 1 was 6 X 14 and Grid 2, located 300 m to the east, was 6 X 15. One Fitch live trap (Rose 1973) baited with wildbird seed and sunflower seed was placed at 7.6 m intervals at the coordinates on the grids. We checked traps for three mornings every two weeks and newly caught small mammals were given uniquely numbered ear tags. Standard information on reproductive condition, body mass, and location was collected for all animals in the manner of Krebs et al. (1969). We released all animals at the point of capture, except for shrews, which usually died in the traps; some rodents (ca. 5-8) were removed from traps and killed by predators. There was no other trap-induced mortality. Trappability, the proportion of animals captured during a given month known to be alive in that month, was high (>75%), indicating that populations were being adequately censused (Hilborn et al. 1976). Despite high trappability, more than half of tagged rodents were not recaptured, i.e., they were transients. So few were recaptured multiple times that we defined residents as any animal caught in a later trapping period. In the calculation of home range, we used the inclusive boundary strip method of Stickel (1954), which adds a strip equal to one-half of the inter-trap interval to the smallest area enclosing stations of capture. Thus, the trappable area of Grid 1 was 0.38 ha and that of Grid 2 was 0.40 ha, values that also will be used in the calculation of density.

Because small mammals are known to respond to the structural habitat produced by a variety of microhabitat variables (M'Closkey 1976, Dueser and Shugart 1978), we measured a set of habitat variables on each grid. We sampled the vegetation of both grids at the end of the growing season in September, using a point-intercept method (Müller-Dombois and Ellenberg 1974) with a modified point-frequency frame. Our sampling frame consisted of a 2.1 m long pole attached to a tripod at the center point, with holes placed at 25 cm intervals. We centered the tripod over the trap station and then dropped eight steel rods marked at 10 cm intervals through the holes. We recorded the highest point of contact on each rod for both woody and herbaceous species. We also recorded the number of stem contacts per each 10 cm interval for the rods located 50 cm from the center point. The frame was then rotated 90° and the process repeated. We used this sampling method because the characteristics of each trapping station rather than the generalized structure of the vegetation of the entire grid could be measured.

Using these and other measurements (Table 1), we recorded 12 non-redundant habitat variables for each of the 174 trapping stations. We selected these variables because they provided vegetative information either known or believed to influence distributions of small mammals (e.g., M'Closkey 1976, Dueser and Shugart 1978). Discriminant function analysis (DFA) of the 12 habitat variables, computed with the discriminant procedures of SPSS (Nie et al. 1975), was used to describe microhabitat

TABLE 1. The 12 habitat variables used for the analysis of habitat structure; the first five were measured or estimated, the remainder determined from vegetation contacts on points of a sampling frame

MNEMONIC	VARIABLE	ASSESSMENT
AVVH	Average vegetation height	Estimation of vegetative height in a 1-m radius at the trap
MAXVH	Maximum vegetation height	Estimation of tallest vegetation in a 1-m radius of the trap
HTV	Height of tallest vegetation	Estimation of tallest vegetation in a 2-m radius of the trap
LIT	Litter depth	Average depth of litter within a 1-m radius of the trap
AVF	Average distance to forest edge	Distance from trap to forest edge
STD1	Stem density, first interval	Number of vegetative contacts between 0 and 20 cm from ground surface on the steel rods located 50 cm from the center point of the tripod
STD2	Stem density, second interval	Same as STD1, but 21-40 cm from ground surface
STD3	Stem density, third interval	Same as STD1, but 41-60 cm from ground surface
STD4	Stem density, fourth interval	Same as STD1, but 61-80 cm from ground surface
STD5	Stem density, fifth interval	Same as STD1, but 81-100 cm from ground surface
PCW	Percent woody vegetation	% of steel rods of sampling frame with woody contacts
PCH	Percent herbaceous vegetation	Percent herbaceous vegetation

differences in the 10 species of small mammals that were trapped. The mark-recapture data were analyzed using programs developed by Krebs (1999), which determined Minimum Number known to be Alive (MNA), an estimate of population density for each species. Chi-square tests and correlation analysis were used, also with SPSS.

RESULTS

The small mammal community and population density:

With only two southern bog lemmings being tagged on Grid 1 and 11 others on Grid 2 (Fig. 1), a population study of *Synaptomys cooperi* was not possible. Furthermore, lemmings were only present for two months on Grid 1 and for five consecutive months at the end of the study on Grid 2. The highest calculated density on Grid 1 was 5/ha and on Grid 2 ca. 18-20/ha. Relatively little information on

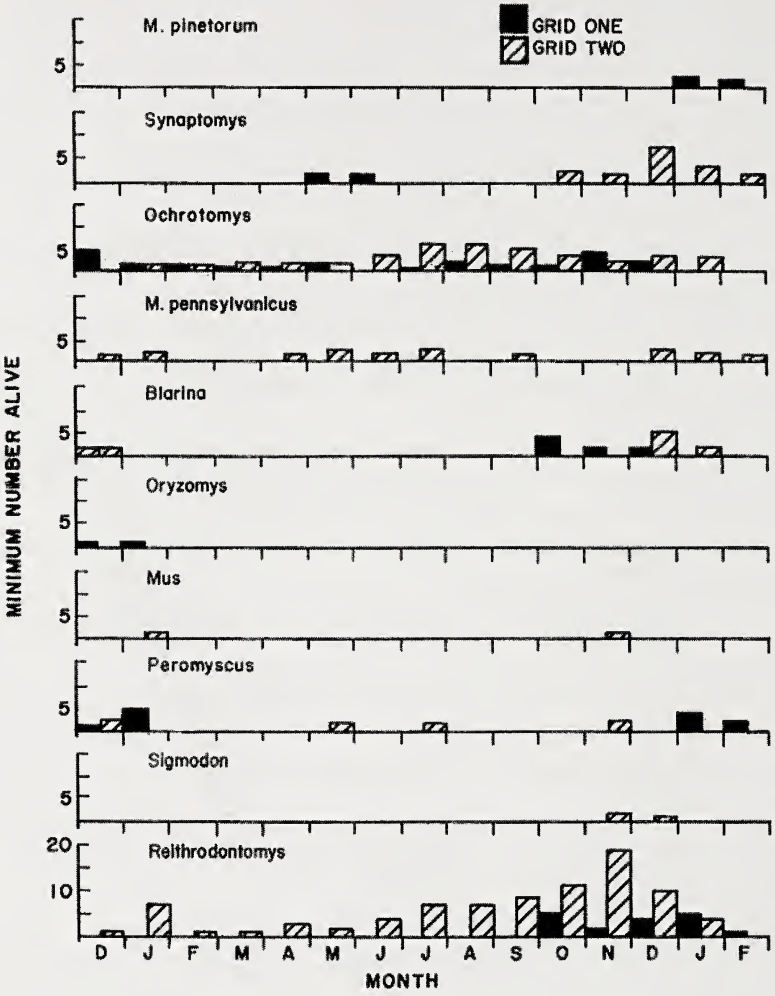

FIGURE 1. Minimum number known alive (MNA) estimates of 10 species caught by live trapping on two grids in the openings under a powerline in the Great Dismal Swamp National Wildlife Refuge, Virginia. The 15 mo of trapping began in December.

reproduction, residency patterns, movements or home range could be gleaned from so few observations.

In all, 155 different small mammals of 10 species were trapped during 12,354 trap nights over the 15-mo study (Table 2). Grid 1 yielded seven species and Grid 2 eight species but only five species were common to both grids. The nine rodents represent the entire small rodent fauna of eastern Virginia. Only one shrew, the short-tailed

TABLE 2. Number of individuals [number of captures] for each species from Grids 1 and 2 (total number of trap nights) in the Great Dismal Swamp National Wildlife Refuge, Suffolk, Virginia.

Small mammal	Grid 1 (5964) Individuals [captures]	Grid 2 (6390) Individuals [captures]	Total individuals
Eastern harvest mouse	14 [24]	57 [89]	71
Golden mouse	10 [20]	12 [47]	22
White-footed mouse	9 [30]	5 [5]	14
Southern bog lemming	2 [2]	11 [23]	13
Meadow vole	0 [0]	13 [29]	13
Short-tailed shrew	7 [7]	7 [7]	14
Woodland vole	3 [6]	0 [0]	3
House mouse	0 [0]	2 [4]	2
Hispid cotton rat	0 [0]	2 [4]	2
Marsh rice rat	1 [7]	0 [0]	1
Total individuals	46 [96]	109 [208]	155 [304]
Captures/individual	2.09	1.91	1.96
Total species	7	8	10

shrew (*Blarina* spp.), was detected; the other three shrews in the region are rarely taken in live traps (Rose 2005).

Despite high trappability, our catch rate of 2.44 per 100 trap-nights, where one trap-night equals one trap in place for one night, was exceedingly low, ca. equal to two animals per grid per day. Further, catch rate and density were even lower in the first winter. (In eastern Virginia, winter usually is the period of highest densities of small mammals [Green and Rose, 2009; ongoing field studies].) In the first February (Fig. 1), Grid 1 yielded only one golden mouse (*Ochrotomys nuttalli* [Harlan]) and Grid 2 one each golden mouse and eastern harvest mouse (*Reithrodontomys humulis* [Audubon and Bachman]). March results were similar, and in April, a third species, represented by one meadow vole (*Microtus pennsyvanicus* [Ord]), was added. By May and June, other species and greater numbers were observed, but densities did not

increase substantially until July.

The MNA density estimates were low for all species, except for eastern harvest mice, 20 of which were known alive in November on Grid 2 (Fig. 1), for a peak calculated density of 50/ha. Grid 2, which was dominated to a greater extent by herbaceous vegetation than Grid 1, yielded more than twice the total number of small mammals (Table 2) but only one more species, despite having only 7% more trap nights because of its slightly larger size. Only golden mice and eastern harvest mice were trapped in relatively high numbers on both grids, together comprising 46 and 63 percent of total individuals on Grids 1 and 2, respectively.

Capture information was of interest for three reasons: to determine when each species was present during the 15 mo of study, to detect transiency/residency patterns, and to evaluate the relationship of capture points to vegetation type and structure. Some species were persistent on the grids, but others were not (Fig. 1). Golden mice, meadow voles, and eastern harvest mice were trapped early and regularly throughout the study, but not always on both grids (Fig. 1). Harvest mice were present nearly every month on Grid 2 but absent on Grid 1 for the first 10 months. Similarly, although persistent on Grid 2, meadow voles were never present on Grid 1. Three woodland voles (*Microtus pinetorum* [LeConte]) were caught during months 14 and 15 on Grid 1. Two southern bog lemmings were captured during months 6 and 7 on Grid 1 but on Grid 2, 11 were caught, all in the last five months of study. Short-tailed shrews were caught in months 11-13 on Grid 1, and months 1, 13 and 14 on Grid 2. One marsh rice rat (*Oryzomys palustris* [Harlan]) was caught seven times during the first two months on Grid 1 and one house mouse (*Mus musculus* Linnaeus) was caught in month 2 and another in month 12 on Grid 2. White-footed mice (*Peromyscus leucopus* [Rafinesque]) were caught in months 1, 2, 14, and 15 on Grid 1 and in months 1, 6, 8, and 12 on Grid 2. Two hispid cotton rats (*Sigmodon hispidus* Say and Ord) were caught in months 12 and 13 on Grid 2. Thus, several species were present intermittently and almost always in low numbers. No mammal tagged on one grid was ever caught on the other grid.

Reproductive patterns:

The level of reproduction was assessed by dividing the year into seasons: winter (Dec. – Feb.), spring (Mar. – May), summer (Jun. – Aug.) and autumn (Sep. – Nov.). The duration of the breeding season can be determined only for persistently present species, the others providing only anecdotal evidence. Eastern harvest mice had high levels of breeding in summer and autumn, and even some in winter (Table 3). The breeding seasons of the other common species are more difficult to assess but golden mice probably bred at a higher level than white-footed mice or meadow voles. From spring onward, every adult female golden mouse was judged to be breeding. Across the study for the four common rodents, 35 of 61 (57%) of adult females were breeding (using the criteria of medium-large nipples and slightly-open-to-open pubic symphyses) and 80-95 % of males were judged to be reproductive, using the criterion of descended (scrotal) testes (McCravy and Rose 1992).

Residency patterns and dispersal:

If captured in at least two trapping periods that individual was counted as a resident. For eastern harvest mice, only 24 of 71 (34%) of tagged animals were residents. The values for golden mice (50%), meadow voles (46%) and southern bog lemmings (30%) also indicated that less than half of animals were present as residents in this

TABLE 3. Percentages of reproductive females each season for combined grids. Sample sizes are in parentheses, and "--" means no adult females caught in that season. The problems of small sample sizes are evident in low-density populations.

Species	winter	spring	summer	autumn	winter
Harvest mouse	33 (6)	0 (3)	100 (7)	88 (17)	13 (8)
Golden mouse	0 (2)	100 (1)	100 (4)	100 (3)	100 (1)
White-footed mouse	0 (3)	--	--	--	0 (2)
Meadow vole	--	0 (1)	50 (2)	--	0 (1)

TABLE 4. For the five common rodents, the numbers of male and female transients for Grids 1 and 2. The numbers in parentheses are the total number of tagged animals and %N is the percentage of those animals caught in only one trapping period (= transients).

	Grid 1 transients			Grid 2 transients		
Species	Male	Female	%N	Male	Female	%N
Eastern harvest mouse	4	8	86 (14)	18	18	63 (57)
Golden mouse	7	1	80 (10)	4	10	33 (12)
White-footed mouse	1	2	100 (2)	4	1	0 (5)
Southern bog lemming	1	0	100 (2)	6	2	73 (11)
Meadow voles	--	--	--	5	2	54 (13)
Totals	13	11	69 (35)	37	23	61 (98)

community. (See Table 2 for sample sizes.)

The powerline right-of-way in which the grids were located provided a corridor of suitable habitat for dispersing animals, except perhaps for the forest-dwelling arboreal species. Dispersal was examined by determining the percentage of transients and the

timing of their movements. A transient was defined as an animal caught in only one trapping period. The proportion of transients for the five most numerous rodents was 69% on Grid 1 and 61% on Grid 2 (Table 4). Of these, harvest mice, golden mice and southern bog lemmings all had higher proportions of transients on Grid 1 than on Grid 2, whereas only white-footed mice showed the opposite pattern. (Meadow voles were absent on Grid 1.) These movements were not significantly ($X^2 = 3.05$, n.s.) greater among males (n = 50) than females (n = 34); 54% of transients were male on Grid 1 and 62% on Grid 2. Combined grid data show 58% of male and 50% of female transients were in reproductive condition. Of the 12 juveniles in this study, seven were transients, making these movements of juveniles similar to that of the entire population. Of the 84 transients, 68 (81%) were observed between September and February; these months correspond with periods of highest densities in these low-density populations.

Home range:

The analysis of home range, the area an individual uses during its daily activities, requires multiple captures; only 20 animals of four rodent species were trapped five or more times, enabling a calculation of home range. Eastern harvest mice had home ranges of 0.08 ha (n = 2; Grid 1) and 0.09 ha (n = 4; Grid 2), whereas golden mice had home ranges of 0.23 ha (n = 1; Grid 1) and 0.12 ha (n = 4; Grid 2). The home ranges for other species (n = 1- 4) were from only one grid: white-footed mice, 0.06 ha; marsh rice rat, 0.14 ha; southern bog lemming, 0.10 ha, and meadow vole, 0.13 ha. Thus, residents of the different species with ≥ 5 captures used similarly small areas.

Analysis of vegetation:

Of the 61 plant species on Grid 1, seven dominants accounted for 80% of 1,867 plant contacts, 57% of them woody contacts. Most woody contacts were attributable to American cane, whereas other grasses, especially *Uniola sessiliflora,* sedges of the genus *Carex* and goldenrods (*Solidago* spp.) contributed greatly to the herbaceous vegetation.

On Grid 2, seven of the 33 plant species accounted for 89% of the 1,459 plant contacts. On this grid, the herbaceous component accounted for 87% of contacts and American cane for most of the woody contacts. The common herbaceous plants, different from those of Grid 1, included panic grasses (*Panicum virgatum*), soft rushes (*Juncus effuses, J. tenuis*), cinnamon fern (*Osmunda cinnamomea*), wool grass (*Scirpus cyperinus*), square-pod water primrose (*Ludwigia alterniflora*) and St. John's wort (*Hypericum virginicum*). Thus, the composition of the vegetation differed between the grids, with woody plants contributing 57% of contacts on Grid 1 but only 13% on Grid 2. The dominant herbaceous vegetation also differed between the grids, with only *Panicum* spp. on both lists in >2% amounts. However, even the differences in panic grasses were striking, constituting 2-3% of herbaceous contacts on Grid 1 but > 52% of herbaceous contacts on Grid 2.

Correlations were run on each of the 12 habitat variables (see Table 1) to analyze the degree of correlation between each of the possible pairs. Most of the pairs had relatively low values ($r < 0.5$ for 123 of the 132 correlations) and therefore show a non-redundancy of information.

Two significant ($P < 0.05$) discriminant functions (DF) were produced for each grid. For Grid 1, DF1 contributed 37% of the discrimination information and DF2 another 36%, explaining 73 percent of the variation. For Grid 2, DF1 contributed 70 percent and DF2 16 percent to explaining the variation.

The discriminant functions are interpreted ecologically by analysis of correlations between the habitat variables and each discriminating function. The more strongly a variable is associated with a particular function, the greater its contribution to that DF.

For Grid 1, the variables (Table 1) most strongly (and significantly) correlated with DF1 were AVF (r = 0.60), STD3 (r = 0.35), PCW (r = -0.33), PCH (r = 0.32) and AVVH (r =-0.30). This discriminant function describes a gradient from a less dense woody forest edge to a more densely herbaceous area away from the forest. DF2 was most strongly correlated with LIT (r = -0.33) and STD3 (r = 0.30). Structurally this is a gradient from an area with a high amount of litter and low stem density from 41-60 cm (such as is seen along a forest edge) to one with little litter and many stem contacts at that level (as would be expected in an open grassy area).

On Grid 2, DF1 was most strongly correlated with AVF (r = 0.78), but other significant variables included PCH (r = 0.54), HTV (r =-0.50), PCW (r = -0.48), STD1 (r = 0.46) and MAXVH (r = -0.43). Structurally DF1 describes a gradient similar to that of Grid 1, from a woody forest edge to a more open grassy area. The four habitat variables most strongly associated with DF2 were STD2 (r = 0.70), STD5 (r= -0.45), AVF (r =-0.36) and STD4 (r = -0.35). DF2 represents a gradient from a forested edge to a dense lower layer and sparse upper layer toward a more open area with sparse lower and dense upper layers.

Species centroids were calculated by using the grand mean and standard deviation to determine if the species were high, low, or intermediate for the variable. Species were then placed on the DF axis based on the location of the centroid of each species (Figs. 2 and 3). The white-footed mouse was present in those areas of both grids with low PCH and AVF and high PCW (Figs. 2 and 3), as would be expected for a forest-dwelling arboreal species. The golden mouse, a semi-arboreal species, was below average for AVF and PCH and above average for PCW on both grids, conforming to its usual association along a forest edge. By contrast, the eastern harvest mouse on both grids had above average values for AVF and PCH and below average values for PCW, indicating its use of the central parts of the grids, away from the forest edge and its woody vegetation and in areas with amounts of herbaceous vegetation. The meadow vole showed similar associations with herbaceous vegetation, especially at levels that provide cover as well as food. The southern bog lemming had intermediate values for all habitat variables on Grid 1, but on Grid 2, where the species was more numerous, low PCH and high PCW indicated an association with patches of American cane.

DISCUSSION

The small mammal community and population density:

Most species of small mammals in these communities were characterized by low population densities, except for eastern harvest mice and golden mice. One possible explanation for the low densities of some species is that the mammals were not sampled effectively. However, in a study of grassland small mammals in eastern Kansas, Fitch traps of the type used in our study were comparable or superior to Sherman live traps (in side-by-side comparisons) in their effectiveness (Rose et al. 1977). In that study, the trap types were equally effective for southern bog lemmings (112 for Fitch, 94 for Sherman) but twice as many white-footed mice were taken with Fitch traps, and for harvest mice the totals were 705 vs 118. With high trappability (>75%), we are

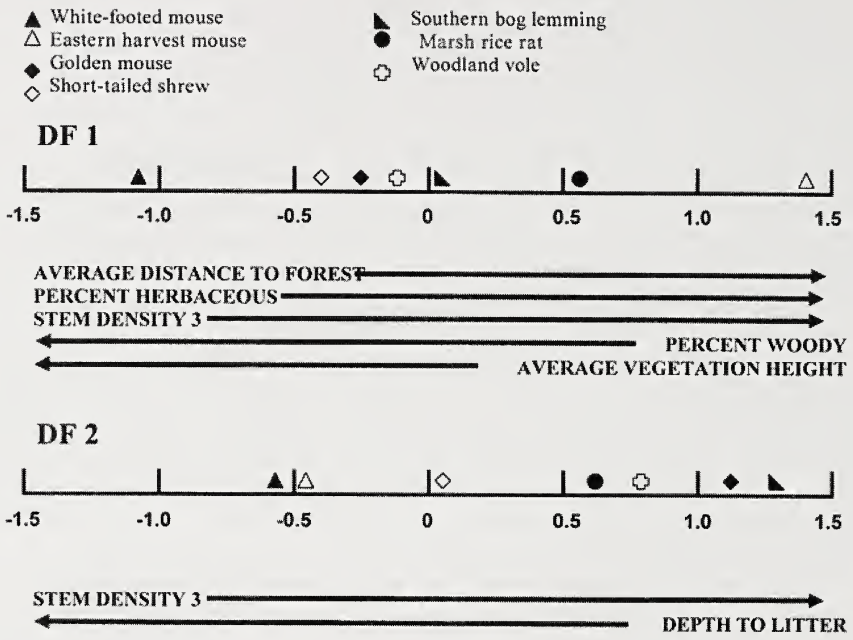

FIGURE 2. Primary variables and the location of small mammal species on each discriminant axis from Grid 1. The variable increases in value in the direction of the arrow. DF 1 explained 37% and DF 2 36% of the variation.

confident that the observed low densities in the Dismal Swamp habitat are real.

The low numbers and long absences of southern bog lemmings on the grids were puzzling. Before establishing our study grids we had detected their presence by their unique green feces (Linzey 1983) and associated piles of cuttings. So we knew they were present. Lemmings apparently strip and eat the green covering of soft rushes (*Juncus*), leaving behind spaghetti-like strands of white pith near their green fecal pellets. Lemmings were reluctant to enter traps until the last winter, a behavior also observed by Connor (1959) in the swamps of the New Jersey Pine Barrens; he caught only 38 in live traps during his 4-y field study using Sherman traps.

Of the 10 species of small mammals recorded during the study, golden mice (n = 22) were relatively numerous but only eastern harvest mice (n = 71) could be considered abundant, especially on Grid 2. Even this species was absent on Grid 1 for the first 10 months (Fig. 1). The last four species in Table 2 had three or fewer individuals, hardly representing established populations. Four other species, with 10-14 individuals, were present: only on one grid (meadow vole), for a short period on one or both grids (southern bog lemming and short-tailed shrew) or intermittently (white-footed mouse; Fig. 1).

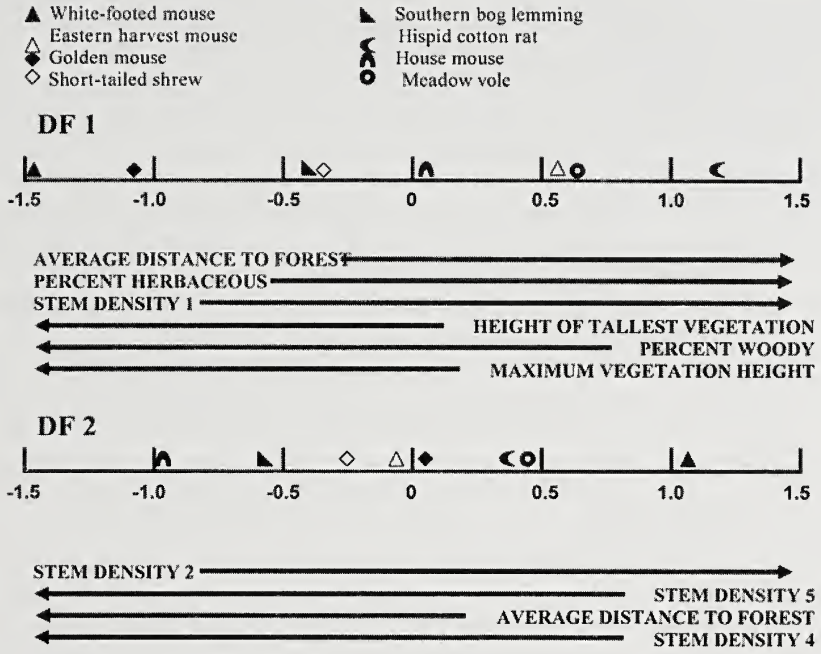

FIGURE 3. Primary variables and the location of small mammal species on each discriminant axis from Grid 2. The variable increases in value in the direction of the arrow. DF 1 explained 70% and DF 2 16% of the variation.

In any month, the population density of any species usually was low (Fig. 1). For the species with 10-14 individuals, only once or twice was the monthly density > 15/ha. The golden mouse, the most persistent on both grids, had highest densities of ca. 12/ha on Grid 1 and 18/ha on Grid 2. These densities for golden mice are higher than those reported in the majority of population studies for this species (review: Rose, 2008). In the two longest population studies of the golden mouse, Linzey (1968) reported a high density of 1.5/ha in one year and 0.2/ha the next in Tennessee, and McCarley (1958) recorded highest densities of 4.72/ha in the first year and 6.24/ha in the second, in Texas. Densities similar to ours were reported, all in Tennessee, by Kitchings and Levy (1981) of 12/ha in summer and 15/ha in autumn and by Seagle, who found 17.2/ha in one summer (1985a) and 18.8/ha in another summer (1985b).

On Grid 2, the eastern harvest mice achieved a high density of ca. 45/ha, similar to the 44.5/ha in an oldfield study (Cawthorn and Rose 1989), also conducted in eastern Virginia. Dunaway (1968), who trapped a 4-ha oldfield near Oak Ridge, Tennessee, reported maximum densities of < 5/ha. Although moderate densities of the semi-arboreal golden mice (reviewed above) and white-footed mice (e.g., Batzli 1977,

among others) were observed during the first half of the study, most species had relatively low densities during this period. This was a time of drought, which may have allowed some species, especially eastern harvest mice and golden mice, to become established in a place they normally would not occupy, and when the normal rains returned in summer, these species responded by increasing density during the autumn. Densities tended to be higher in the latter half of the study, most noticeably for eastern harvest mice and southern bog lemmings on Grid 2.

Reproductive patterns:

The low densities and absence of juvenile animals indicated a lack of recruitment via either reproduction or immigration early in the study. However, by mid-summer, evidence of increased reproduction was seen both in reproductive indices and in the greater recruitment of juveniles and immigrants. For the five most common rodents, the level of breeding across the study was typical of these species: 57% for females and 80-95% for males. Descended testes are a useful indicator of fertility in males, as are medium-large nipples and separated pubic symphyses in females (McCravy and Rose 1992). Thus, although the densities in this community were low, the level of breeding probably was typical of other populations of each species in the region (e.g., Bergstrom and Rose 2004, Cawthorn and Rose 1989, Green and Rose 2009, Rose et al. 1990, Rose and Mitchell, 1990), but few juveniles entered the trappable population.

Residency patterns and dispersal:

Despite frequent trapping and high trappability, the majority of animals tagged in our study were never seen after the trapping period in which each was first captured. For the five most common rodents (Table 4), less than half of tagged animals were residents on Grid 1 (38%) and Grid 2 (46%), despite the liberal definition we used for residency. Many investigators require three months as the minimum period for animals to qualify as residents (e.g., Dueser et al. 1981, Rose and Kratimenos 2006), but our definition used only two trapping periods, or one month. Thus, all species in this community showed minimal evidence of settlement.

Home range:

The home ranges of the few animals whose areas could be calculated were small, mostly ca. 0.10 ha. The home ranges of the eastern harvest mouse (0.08, 0.09 ha for Grids 1 and 2) were similar to those of Cawthorn and Rose (1989), also using a minimum of five captures: 0.09 ha for males and 0.11 ha for females. The home ranges of the golden mouse (0.23 and 0.12 ha) were in the range of those observed by Dunaway (1955: 0.11 ha), Redman and Sealander (1958: 0.13 ha) and Linzey (1968: 0.25 ha), but smaller than those of McCarley (1958: 0.58 ha), Blus (1966: 0.57 ha) and Faust et al. (1971: 0.66 ha). Although we were able to calculate home range estimates for four species, we cannot claim these values to be representative because of small sample sizes (n = 1-4) and of few animals having more than the minimum of five observations. Home range estimates increase linearly with the number of observations (e.g., Linzey, 1968), so our values can be interpreted as minimal values.

Analysis of vegetation:

DFA describes the average microhabitat configuration for a given species and determines which variables are important for developing that configuration (Dueser and Shugart 1979). DFA has been used in a number of studies to analyze how species separate themselves in space, each using structurally distinctive microhabitats (e.g.,

Dueser and Shugart 1978). When the values for the species' centroids were plotted along an axis with the significant variables associated with each DF (Figs. 2 and 3), interpretable microhabitat features were observed. For example, the arboreal white-footed and golden mice had low values for percent herbaceous and high values for both percent woody and vegetation height (Figs. 2 and 3), whereas the grassland species (eastern harvest mice and meadow voles) showed strong associations with low percent woody contacts and high values for percent herbaceous vegetation. Species known to have broader habitat tolerances, such as short-tailed shrews and southern bog lemmings, showed less interpretable placement along the axes. In brief, the results of our vegetation analyses were consistent with what is known about the kinds of microhabitats associated with each species.

General discussion:

Low-density populations face several problems, including high extinction rates from stochastic events (Smith et al. 1978). The irregular or intermittent presence of low numbers of southern bog lemming and short-tailed shrew may be interpreted as the disappearance of tiny populations, resulting in local extinctions. Woodland vole, marsh rice rat, house mouse, and hispid cotton rat were only briefly present, never really establishing viable populations, and part of communities in which 69% and 61% (on Grids 1 and 2, respectively) of individuals were tagged but never seen again. Migration and perhaps mortality rates were high in this study. Age distributions were unstable, for despite frequent trapping only 12 of 155 animals were judged to be juveniles. This low proportion also suggests a relatively low level of recruitment of young animals, if not also of successful reproduction. Thus, the predictions of Smith et al. (1978) relating to low-density populations, namely of high extinction rates, high (gross) mortality, low recruitment of juveniles, and unstable age distributions, were observed.

The mere presence of a species does not support the claim of habitat suitability. The one or two woodland voles, marsh rice rats, house mice, and hispid cotton rats likely were transients, merely passing through our grids, sometimes pausing for a second month, as in the case of the one marsh rice rat caught seven times on Grid 1. Other species, such as southern bog lemmings and short-tailed shrews, seemed to establish populations on one or both grids, but for variable lengths of time. Only eastern harvest mice, golden mice, and perhaps meadow voles established what could be considered persistent populations on one or both grids, but even they, except probably for harvest mice, would be subject to stochastic events and thus prone to local extinctions.

In conclusion, the small mammal communities on our two grids included all the common small rodents and the one trappable shrew in eastern Virginia, but most species were represented by few individuals, were not always present on both grids, and all species exhibited a high degree of transiency. Four species were represented by one or two individuals and showed no evidence of settlement. Three rodents and the shrew were present as low-density populations, whereas only golden mice and eastern harvest mice had modest-to-high densities, indicating potentially permanent populations. Yet even these latter two species showed high proportions of transients, which was puzzling, and were mostly adult animals, neither of which is representative of self-sustaining populations.

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The Effects of Thawing Procedure and Supplementation on the Motility and Viability of Frozen-thawed Boar Semen

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ABSTRACT

The effect of two thawing procedures on frozen boar semen and supplementations to the fertilization media were studied. Frozen boar semen was thawed using either Percoll gradient or phosphate buffered saline (PBS) procedure. Supplementations were 1.0 mM L-glutamate, 1.0 mM N-acetyl-cysteine (NAC), and 1.0 mM NAC-amide (NACA). Spermatozoa were analyzed for forward progressive motility (FPM) and viability every 0.5 h for 3.0 h post-thawing. There were significantly ($P < 0.05$) higher numbers of viable (76.0 ± 5.1%) and FPM (30.0 ± 2.4%) spermatozoa at 3.0 h post-thawing using the PBS procedure compared to the Percoll gradient thawed spermatozoa (65.0 ± 3.9%; 10.0 ± 4.5%, respectively). Supplementation of 1.0 mM L-glutamate, 1.0 mM NAC, or 1.0 mM NACA had no significant effect on spermatozoa viability regardless of the time post-thaw. Supplementation of 1.0 mM L-glutamate, 1.0 mM NAC, or 1.0 mM NACA had no significant effect on FPM up to 1.0 h post-thaw. Spermatozoa with no supplementation or 1.0 mM L-glutamate had significantly higher ($P < 0.05$) FPM compared to the 1.0 mM NAC and 1.0 mM NACA supplemented groups at 1.5, 2.0, 2.5, and 3.0 h post-thaw. There was no significant difference between no supplementation or 1.0 mM L-glutamate on FPM regardless of the time post-thaw. There was no significant difference between 1.0 mM NAC or 1.0 mM NACA on FPM regardless of the time post-thaw. These results indicate that thawing procedure has an effect on spermatozoa viability and FPM but supplementation does not have an effect on the overall viability of spermatozoa during thawing, but may reduce FPM.

INTRODUCTION

Swine are valuable to science because they serve as a comparable model for human anatomy and physiology research. Research using swine as the experimental model often utilizes *in vitro* techniques to limit the experimental variability observed *in vivo*. The *in vitro* production of embryos is not as efficient as its natural counterpart, as a result of a decrease in the fertilization success rate during *in vitro* fertilization (IVF) and a reduction in viable IVF-derived embryos (Abeydeera 2002).

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Inefficiencies associated with *in vitro* production can be divided into two categories, the technique used to thaw frozen semen (Henkel et al. 2003, Chou et al. 2005) and the resulting media in which the semen is extended and cultured (Armstrong et al. 1999). Semen can be thawed using a saline wash procedure (Whitaker and Knight 2004, Chou et al. 2005) or Percoll gradient separation (Henkel et al. 2003). Both methods have variable results between replications and neither is close to the results obtained from fresh semen (Henkel et al. 2003). Current speculation is that oxidative stress during the freezing and thawing of semen produces large amounts of reactive oxygen species (ROS) that effects spermatozoa motility (Armstrong et al. 1999) and nuclear DNA (Fraser and Strzezek 2005).

Antioxidants supplemented to the semen extender have been shown to improve the viability of the spermatozoa (Funahashi et al. 2005) and perhaps lessen the harmful effects of the free radicals on the spermatozoa (Blount et al. 2001). One antioxidant of interest is N-acetyl-cysteine (NAC) because it reduces cystine to cysteine, thus modulating glutathione (GSH) biosynthesis (Nakata et al. 1996, Issels et al. 1998); and has the ability to supply its sulfhydryl group to enhance glutathione-S-transferase activity (Nakata et al. 1996), which attaches glutathione to various compounds. N-acetyl-cysteine has been implicated in protecting against oxidative stress as seen when supplemented during the later stages of embryo development by decreasing the incidence of early fetal death (Xu et al. 2005). A derivative of NAC, NAC-amide (NACA) is of interest because the amide addition neutralizes the otherwise negatively charged carboxyl group, allowing it to permeate most physiological membranes. Research has shown that NACA is able to replenish intracellular GSH and defend cells against oxidation (Grinberg et al. 2005, Wu et al. 2006).

Therefore, the objectives of this study were to, 1) determine the effects of two different thawing procedures on spermatozoa viability and forward progressive motility (FPM), and 2) determine the effects of 1.0 mM L-glutamate, NAC, and NACA supplementation to the thawing media on spermatozoa viability and FPM.

MATERIALS AND METHODS

Media

Unless otherwise stated, all chemicals were purchased from Sigma-Aldrich Co. (St. Louis, MO, USA). The Modena medium (152.6 mM glucose, 23.46 mM Na-citrate, 11.9 mM Na-carbonate, 6.99 mM EDTA, 26.66 mM Tris, and 15.1 mM citric acid) was adjusted to pH 7.3. The PBS thawing medium was Dulbecco's phosphate buffered saline (PBS) (Invitrogen, Carlsbad, CA, USA) containing 75 µg/mL potassium penicillin, 50 µg/mL streptomycin sulfate, and 0.1% BSA (fraction V; 43H1097, initial fraction by heat shock). The fertilization medium was a modified Tris-buffered medium (mTBM) formulated by Abeydeera and Day (1997). The NACA was supplied by Novia Pharmaceuticals Ltd. (Haifa Bay, Israel).

Semen

Frozen semen was obtained from Swine Genetics International Ltd. (Cambridge, IA, USA). The semen was extended using a yolk-based media and frozen in 5.0 mL straws in a Cryo-Med chamber to control the freezing rate. Upon arrival in the laboratory, straws were cut into 1.0 cm long pellets and stored in liquid nitrogen until use. All semen used was from the same boar but not from a single collection.

Semen thawing using Percoll gradient

A frozen semen pellet was thawed in 2.0 mL Modena and then overlain on a Percoll gradient (2.0 mL 90% Percoll medium (v:v, Modena) overlain with 2.0 mL 45% Percoll medium (v:v, Modena)). The gradient was centrifuged at 700 x *g* for 20 min. The semen was then washed by centrifugation at 500 x *g* for 5 min in mTBM. After washing, the spermatozoa pellet was re-suspended with mTBM to a concentration of 4 x 10^5 spermatozoa/mL and incubated at 39°C in 5% CO_2 until analysis.

Semen thawing using PBS wash

A frozen semen pellet was thawed as previously described (Whitaker and Knight 2004). Briefly, the semen pellet was thawed in PBS at 39°C and centrifuged at 36.3 x *g* for 5 min. The semen was then washed by centrifugation twice at 553 x *g* for 5 min. After washing, the spermatozoa pellet was re-suspended with mTBM to a concentration of 4 x 10^5 spermatozoa/mL and incubated at 39°C in 5% CO_2 until analysis.

Viability staining

Membrane integrity was assessed by staining spermatozoa with Eosin red and Aniline blue dye and then smeared on a microscope slide to determine viability. Spermatozoa that had intact membranes did not incorporate the dye and stained pink, whereas spermatozoa that had degraded membranes incorporated the dye and stained purple (Colenbrander et al. 2002). A total of 100 cells were counted for each pellet analyzed using a phase-contrast microscope at 400X magnification.

Motility

Forward progressive motility was analyzed by placing 20 µL of spermatozoa in 0.1 M sodium citrate buffer (v:v) on a 38°C glass slide. A total of 100 cells were either classified as either FPM or non-FPM for each pellet analyzed using a phase-contrast microscope at 400X magnification.

Experiment 1: Comparison of semen thawing methods on spermatozoa viability and FPM

A frozen semen pellet was thawed using either the PBS wash or the Percoll gradient procedure and then analyzed for viability and FPM at 3.0 h post-thawing. For this experiment a total of 60 semen pellets were used, by thawing and analyzing 30 pellets for each procedure.

Experiment 2: Comparison of fertilization media supplements on spermatozoa viability and FPM

Based on the results from Experiment 1, a frozen semen pellet was thawed using the PBS wash procedure and incubated in mTBM supplemented with either 1.0 mM L-glutamate, NAC, or NACA for 3.0 h. Spermatozoa were analyzed for viability and FPM every 0.5 h for 3.0 h post-thaw. For this experiment a total of 90 semen pellets used, by thawing and analyzing 30 pellets for each supplement.

Statistical Analysis

Data in both experiments were analyzed by one-way ANOVA using the PROC ANOVA procedures of SAS (SAS Institute, Cary, NC) because the data were balanced in all cases. When there was a significant effect of treatment, significant differences were determined using LSMEANS statement and Tukey adjustment for multiple comparisons. The effects included in the model were treatment and technician. Technician effects were not significant ($P < 0.05$) and deleted from the final model. A probability of less than 0.05 ($P < 0.05$) was considered significant.

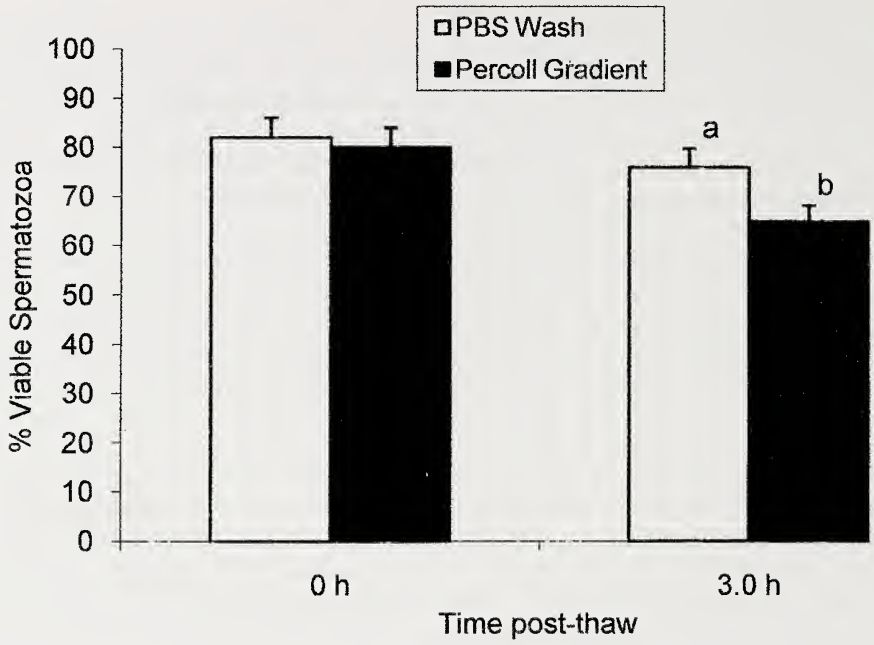

FIGURE 1. Effect of thawing procedure on spermatozoa viability after thawing (0 h) and 3.0 h post-thawing. PBS Wash, phosphate buffered saline wash procedure; Percoll gradient, Percoll gradient wash procedure. Data are expressed as mean ± SE. [a,b] Means with different superscripts at a given time differ at least $P < 0.05$.

RESULTS

Experiment 1: Comparison of semen thawing methods on spermatozoa viability and FPM

There were no significant differences in viability or FPM between the PBS wash and Percoll gradient thawed semen immediately after thawing. At 3.0 h post-thaw there were significantly ($P < 0.05$) higher numbers of viable spermatozoa from the PBS wash thawing procedure (76.0 ± 5.1%) compared to the Percoll gradient thawing procedure (65.0 ± 3.9%) (Figure 1). At 3.0 h post-thaw there were significantly ($P < 0.05$) higher numbers of FPM spermatozoa from the PBS wash thawing procedure (30.0 ± 2.4%) compared to the Percoll gradient thawing procedure (10.0 ± 4.5%) (Figure 2).

Experiment 2: Comparison of fertilization media supplements on spermatozoa viability and FPM

There was no significant effect of 1.0 mM L-glutamate, 1.0 mM NAC, or 1.0 mM NACA supplementation on viability at any time h post-thaw. There was no significant effect of 1.0 mM L-glutamate, 1.0 mM NAC, or 1.0 mM NACA supplementation on

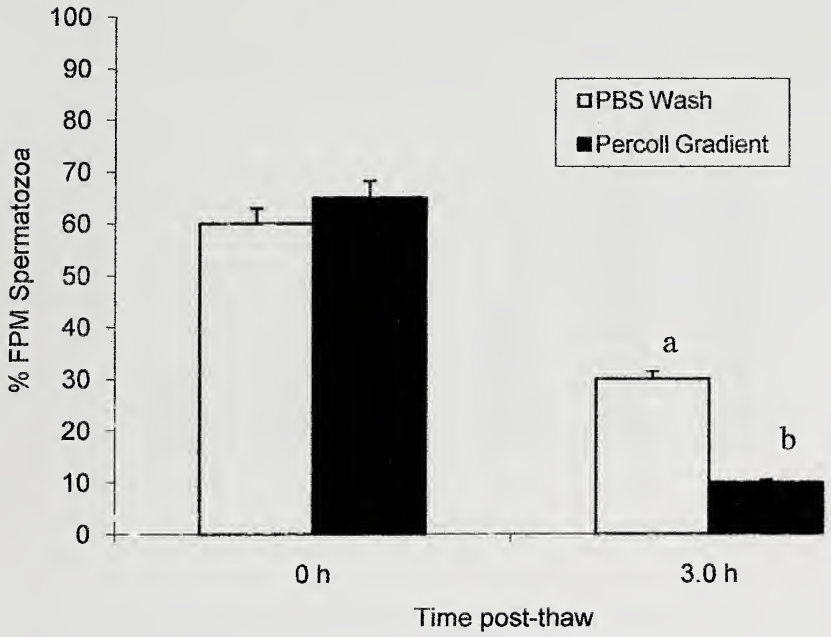

FIGURE 2. Effect of thawing procedure on spermatozoa forward progressive motility (FPM) after thawing (0 h) and 3.0 h post-thawing. PBS Wash, phosphate buffered saline wash procedure; Percoll gradient, Percoll gradient wash procedure. Data are expressed as mean ± SE. [a,b] Means with different superscripts at a given time differ at least $P < 0.05$.

FPM at 0, 0.5 and 1.0 h post-thaw. Supplementation of 1.0 mM L-glutamate elicited significantly higher ($P < 0.05$) FPM compared to other supplementations at 1.5, 2.0, 2.5, and 3.0 h post-thaw (Figure 3). There was no significant difference between the 1.0 mM NAC and 1.0 mM NACA supplemented groups.

DISCUSSION

Our results indicate that thawing frozen semen pellets using the PBS wash procedure produce greater numbers of viable and FPM spermatozoa by 3.0 h after thawing compared to the Percoll gradient thawed semen (Figures 1 and 2). Our rates of success are similar to previous research (Henkel et al. 2003, Chou et al. 2005) but neither of those studies directly compared thawing procedures. Greater emphasis is placed on studying different semen freezing protocols (Grossfeld et al. 2008) and thawing protocols based on temperature (Paulenz et al. 2007) rather than thawing techniques. The temperature used to thaw frozen boar semen is well documented (Abeydeera 2002) and our results strengthen this recommendation. Additionally, our results from experiment 1 provide evidence that there might not be a definitive technique to thaw frozen boar semen, but rather the technique that causes the highest

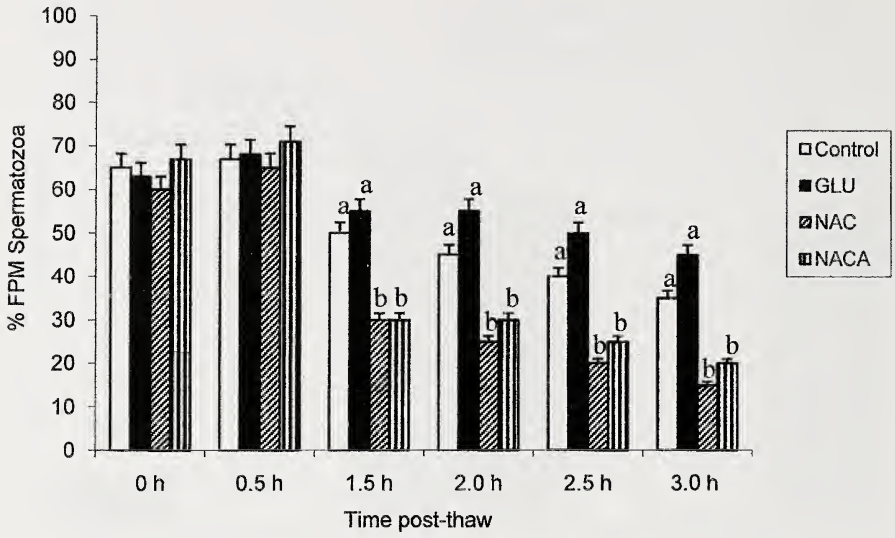

FIGURE 3. Effect of supplementation to the fertilization media on spermatozoa forward progressive motility (FPM) at 0, 0.5, 1.5, 2.0, 2.5, and 3.0 h post-thawing. Control, no supplementation to fertilization media; GLU, 1.0 mM L-glutamate supplementation; NAC, 1.0 mM N-acteyl-cysteine supplementation; NACA, 1.0 mM N-acetyl-cysteine-amide supplementation. Data are expressed as mean ± SE. [a,b] Means

viability and FPM for the researcher should be employed. This could be different between researchers and not allow for a standardized thawing technique. Our results (Figures 1 and 2) indicate that the PBS thawing procedure is best for our research.

Results of experiment 2 indicate that supplementing 1.0 mM NAC or NACA significantly ($P < 0.05$) decreased FPM 1.5 h after thawing but did not affect spermatozoa viability (Figure 3). The decrease in FBM could be related to the effect of antioxidants on the function of the spermatozoon tail. A spermatozoon is propelled by a flagellum to reach and fertilize the oocyte. Energy required for this action is obtained in part from the large numbers of mitochondria found near the base of the tail (Eddy and O'Brien 1994). The supplementation of 1.0 mM NAC or NACA may specifically cause a detrimental effect to the mitochondria such as decondensation and degradation of mitochondrial DNA, thus reducing the motility of the spermatozoa. This explanation however is contrary to other findings that report antioxidants, specifically GSH, increased motility and viability when supplemented to the media (Munsi et al. 2007). The discrepancy could be due to different experimental models (bull versus boar) and perhaps the concentration of antioxidants supplemented. A study evaluating the effects of increasing doses of antioxidants on FPM and viability needs to be completed before further conclusions are made.

Fertilization media is routinely supplemented with caffeine to increase penetration rates of the oocyte (Abeydeera and Day 1997). However, supplementation of caffeine has been shown to increase the incidence in polyspermic penetration (Funahashi et al.

2000). Research has found glutamate receptors in the spermatozoa of humans and mice (Hu et al. 2004) and perhaps these receptors are also found in pig spermatozoa. Our results indicate that supplementation of the excitatory amino acid, L-glutamate did not increase the FPM or viability of spermatozoa after thawing (Figure 3). Further research needs to be done to determine the specific actions and effects of L-glutamate compared to caffeine.

Our results further increase the understanding of semen thawing technology and applicatios of antioxidants. Further research still needs to be done to determine specific doses, and if NAC and NACA are acting as antioxidants in the media or directly on the spermatozoa. A better understanding of the actions of antioxidants during thawing could lead to more successful IVF techniques and methodology.

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A Comparison of Different Methods for Predicting Cancer Mortality Counts at the State Level

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ABSTRACT

Cancer is a major health issue in the United States. Reliable estimates of yearly cancer mortality counts are essential for resourcing and planning. The American Cancer Society has used several methods of forecasting to estimate the future cancer burden and researchers are continually working to develop new methods with improved performance. There have been studies comparing different models for predicting the US cancer mortality counts. This study explores and compares several different models for cancer mortality count predictions at the state level, principally for the state of Virginia. Results of the comparisons appear to show the final improved model to perform better than the others; however, at the state level even the improved model can still produce undesirable results.

INTRODUCTION

Cancer is the main cause in one out of every four deaths in the United States; only heart disease causes more deaths each year (ACS 2008). In 2008 the American Cancer Society (ACS) estimates that 565,650 Americans will die from cancer; 13,990 are expected to be Virginians (ACS 2008). In 2007 the National Institutes of Health (NIH) estimates that the total costs associated with cancer reached $219.2 billion: $89 billion for direct medical costs, $18.2 billion for lost productivity due to illness and $112 billion for lost productivity due to premature death (ACS 2008). As a result of these costs it is vital for many agencies to have precise estimates of cancer incidence and mortality counts for resourcing and planning. Agencies need to have reliable predictions in order to budget annually for cancer research, treatment, prevention, and other related expenditures.

The National Center for Health Statistics (NCHS) of the Centers for Disease Control (CDC) publicly releases the observed mortality data compiled from death certificates certified by attending physicians, funeral directors, medical examiners, and coroners. The latest data available are 3 years old due to the large number of records involved and the complex process of data collection, tabulation, and publication. For instance, in 2007 the NCHS released the actual mortality data for 2004. As a result of this procedural delay it is necessary to predict three years ahead to obtain the current year's numbers to budget and plan accordingly.

Each year the ACS releases these predicted figures in two publications, *Cancer Facts & Figures* (CFF) and *CA-A Cancer Journal for Clinicians*. Included in these publications are the projected number of deaths from site and gender specific cancers and all cancers combined at the national and state level. The ACS has used several methods of forecasting to estimate the future cancer burden and researchers are

continually working to develop new methods with improved performance. Prior to 1995, a model based on linear predictions was used by the ACS to estimate the yearly number of cancer deaths. A quadratic time series model with autoregressive errors called the PF model was used from 1995 to 2003. During this time the ACS would make subjective modifications to the forecasts by choosing from five different forecasts in order to account for recent trend changes in the data that the model was not able to capture. The five possibilities for the published forecasts were the three-year-ahead point predictions, the upper and lower 95% prediction limits, and the midpoints between the prediction limits and the point estimate.

In order to improve forecasts, Tiwari et al. (2004) developed a state space model (SSM) based method and its tuned version (tuned SSM). This method was used to obtain cancer predictions published in Cancer Statistics, 2004 (Jemal et al. 2004). The ACS did extensive research at both the national and state levels, and found the tuned SSM to perform better on average than other methods when comparing mean squared deviations, but at the state level the ACS found the PF model and the tuned SSM to be comparable with a slight advantage for the PF model over the SSM. In part because of its ability to adjust well to rapidly changing trends at the national-level, the ACS adopted the tuned SSM for cancer forecast in 2004. Since 2004 the ACS has been using the tuned SSM to predict the yearly cancer mortality counts using the method of moments (MOM) to estimate the error covariance matrices (Tiwari et al. 2004).

In a recent paper, Ghosh et al. (2008) studied the predictions of the 3 methods at the national level and found the tuned SSM to perform better on average, but not uniformly. Apparently, they also studied the models at the state level and found the results were not as favorable to SSM and tuned SSM as at the national level. However, no specific state level results are reported and data used were only up to 2001. In this article, the interest is to compare the three methods specifically for the state of Virginia's cancer mortality data. For this, three more years of data are used than Ghosh et al. (2008), that is years 1969 through 2004 are used to compare cancer mortality predictions through 2007 using these methods.

DATA

Analysis in this article uses Virginia mortality data from years 1969 through 2004, the latest year available at the time of analysis (SEER 2007). The data is broken down by gender and cancer site where specified. The SEER*Stat Software was used to obtain all Virginia mortality data (NCI 2008). The data is in the form of d_t, where $t = 1$ corresponds to the number of cancer deaths in 1969 and $t = 36$ corresponds to 2004.

PF MODEL

From 1995 until 2003, ACS predictions were based on the PF model using a quadratic time trend with autoregressive errors. This model can be written in the form

$$d_t = b_0 + b_1 t + b_2 t^2 + u_t$$

$$u_t = a_1 u_{t-1} + \cdots + a_p u_{t-p} + \varepsilon_t$$

where the ε_t's are independently distributed with mean zero and constant variance σ_ε^2 for all t.

The first step in implementing the PF model is to fit a quadratic time trend model

$$d_t = b_0 + b_1 t + b_2 t^2$$

to the series using ordinary least squares. Then the residuals

$$\hat{u}_t = d_t - (\hat{b}_0 + \hat{b}_1 t + \hat{b}_2 t^2)$$

are calculated and an autoregressive process is fit to $\{\hat{u}_t\}$ in order to capture the short-term fluctuations of the series. In this autoregressive process the residual at a current time point depends on the residuals at previous time points and a random error term (Harvey 1989, 1993). The combined forecasting model is then used to make future mortality predictions.

The PF method needs at least seven observations consisting of d_t and t in order to fit the forecasting model. SAS procedure PROC FORECAST (PF) is used to obtain the three-year-ahead predictions and 95% prediction intervals for each year (SAS 2004). Each year the PF model was applied to gender and site specific groupings (for example male digestive system) and then the overall national-level prediction was a sum of the predictions from all the individual sites. The PF model was also applied at the state level, but to insure that the sum of the state level predictions equaled the national level predictions, the state forecasts were adjusted proportionally when needed.

STATE SPACE MODEL

A state space model (SSM) for representing the yearly number of cancer deaths d_t is

$$d_t = \alpha_t + \varepsilon_t, \; t = 1, 2, \ldots$$

where α_t is the unobserved trend at time t and ε_t is the error at time t. Here ε_t's are assumed to be serially uncorrelated and normally distributed with zero-mean and constant variance $\sigma_\varepsilon^2 = V$.

The PF model was slow in capturing sudden year-to-year variations in the series; to improve on this a trend that changes with time can be implemented. There are several time-varying trends available; a local quadratic trend is selected because of its similarity to the quadratic time series model. The local quadratic trend model is

$$\alpha_t = \alpha_{t-1} + \beta_{t-1} + \gamma_{t-1} + \eta_{1t}$$
$$\beta_t = \beta_{t-1} + 2\gamma_{t-1} + \eta_{2t}$$
$$\gamma_t = \gamma_{t-1} + \eta_{3t}$$

The errors η_{it} are assumed to be serially uncorrelated with mean 0 and variance σ_i^2. They are also assumed to be uncorrelated with each other and with the ε_t's. Further ε_t is called the measurement error and $\boldsymbol{\eta}_t = [\eta_{1t} \quad \eta_{2t} \quad \eta_{3t}]$ is called the transition error with variance **W**. The measurement and transition errors are also assumed to be normally distributed so V and **W** can be estimated using maximum likelihood (ML) estimation. If $\sigma_i^2 \equiv 0$ (i = 1,2,3) then the local quadratic model reduces to $d_t = \alpha_0 + \beta_0 t + \gamma_0 t^2 + \varepsilon_t$. Hence a state space model with a local quadratic trend mimics the PF model.

Following the methods of Ghosh et al. (2008) one can obtain the predicted series

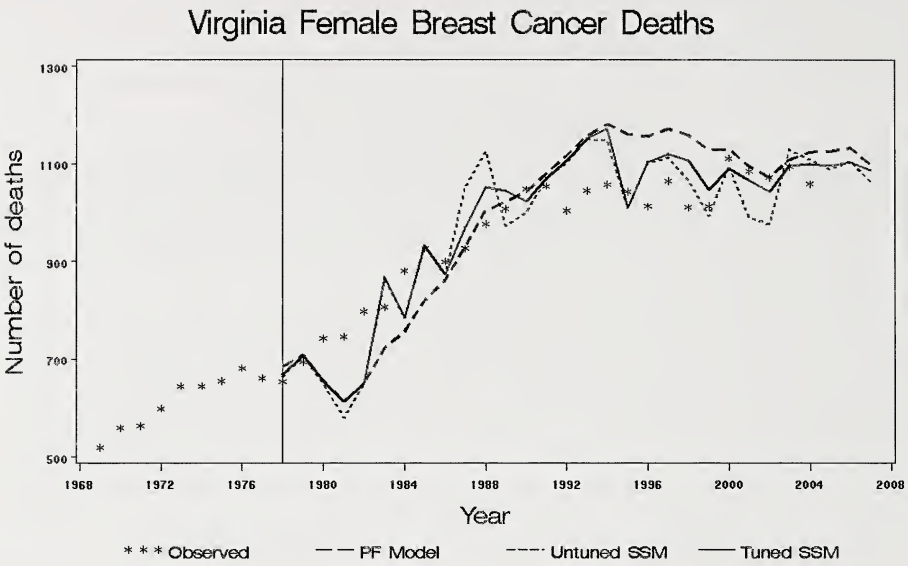

FIGURE 1. Three-year-ahead predictions of female breast cancer deaths for Virginia, 1978-2007, using PF method, SSM and tuned-SSM.

using this SSM. This type of model prediction can be implemented by various packages including *SsfPack2.2*. "*SsfPack* is a suite of C routines for carrying out computations involving the statistical analysis of univariate and multivariate models in state space form" (Koopman et al. 1999).

Figure 1 shows Virginia mortality predictions for female breast cancer using data from years 1969 through 2004. The SSM predictions, PF predictions, and corresponding observed values are all shown. Also shown are the tuned SSM predictions, which will be discussed in the next section. Notice how the SSM adapts faster to the leveling off of the observed series than the PF model which continues to increase for a period of time before it adapts to the new trend. For Virginia female breast cancer the root mean square predicted error (RMSPE) for the SSM is smaller than the RMSPE for the PF model. The SSM is able to adapt faster to trend changes than the PF model. However, small random variations in the observed series are magnified and show up as zigzags in the SSM predictions. This jaggedness is especially noticeable at the state level or in rare cancers. Figure 2 shows female breast cancer mortality predictions for the entire U.S. Notice that even though both SSM predicted series in Figures 1 & 2 are jagged, the predicted series for Virginia's female breast cancer deaths has more severe year-to-year fluctuations than the predicted series for entire U.S.'s female breast cancer deaths.

These exaggerated fluctuations are a weakness of the model, because it creates an uncertainty that can make the predictions useless. Figure 3 shows Virginia testis observed cancer counts and corresponding predictions. Testis cancer has a variable observed series yielding to very erratic predictions from the SSM. For the predicted series shown in the figures, testis cancer has the worst predictions with regards to

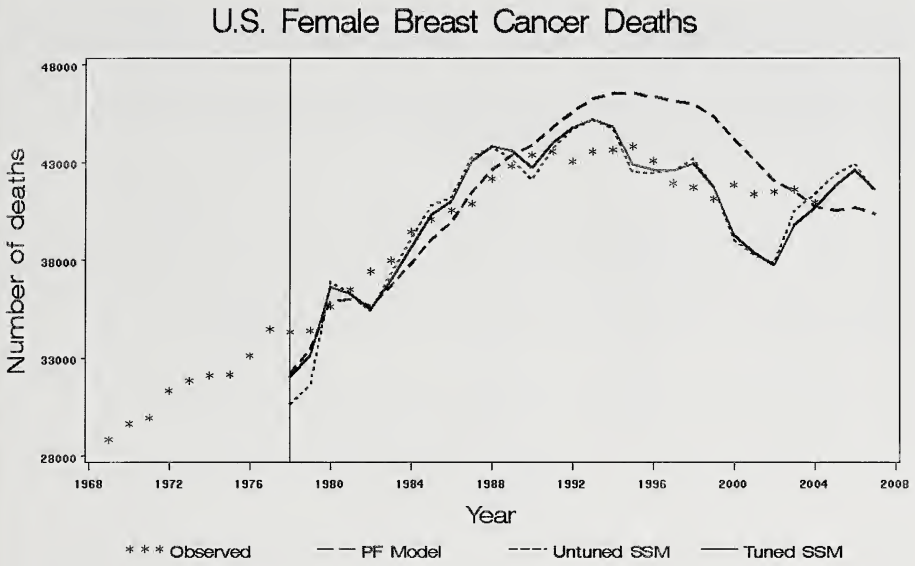

FIGURE 2. Three-year-ahead predictions of female breast cancer deaths for the U.S., 1978-2007, using PF method, SSM and tuned-SSM.

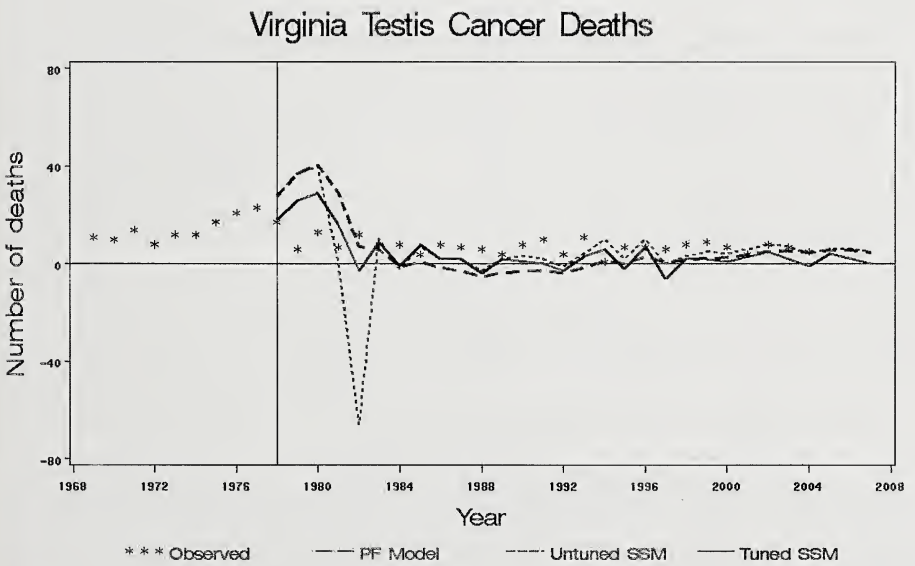

FIGURE 3. Three-year-ahead predictions of testis cancer deaths for Virginia, 1978-2007, using PF method, SSM and tuned-SSM.

RMSPE for both the SSM and the PF model. The SSM model predicts negative mortality counts for 4 different years while the PF model predicts negative counts for 9 years. On the other hand, the SSM predicts -66 people to die from testis cancer in 1982 while the lowest prediction made by the PF method is -5 in 1988. Both of the predicted series for testis cancer are unreasonable.

TUNED SSM

To help control the variability of the SSM, tuning parameters can be introduced into the model. The time-invariant error variances V and **W** are rescaled by the tuning parameters such that the sum of squares of the differences between the predicted mortality counts and the observed mortality counts is minimized.

Let $\hat{d}_t$ be the predicted number of deaths at time t. Let V_t^* be the variance and $\mathbf{W}_t^*$ be the covariance matrix from the SSM, estimated from observed values $d_1 \ldots d_t$ in order to predict $\hat{d}_{t+3}$. The added suffix t refers to the portion of the time series that V and **W** are estimated from, so V and **W** are still time-invariant. To illustrate, $d_1 \ldots d_7$ are used to estimate V_7^*, and $\mathbf{W}_7^*$ then to obtain $\hat{d}_{10}$. Similarly, $d_1 \ldots d_8$ are used to obtain $\hat{d}_{11}$ and V_8^* and $\mathbf{W}_8^*$ are the corresponding covariance matrices used in the prediction. Likewise, computation of V* and **W*** continues until the most recent year available that has a corresponding observed value. For example, if 2004 is the latest year for which the observed number of cancer deaths is known then stop with V_{33}^* and $\mathbf{W}_{33}^*$ which are used to obtain $\hat{d}_{36}$, the estimated number of deaths for 2004. Once $V_7^* \ldots V_{33}^*$ and $\mathbf{W}_7^* \ldots \mathbf{W}_{33}^*$ have been estimated, replace each V_t^* and $\mathbf{W}_t^*$ with $\kappa_v V_t^*$ and $\kappa_w \mathbf{W}_t^*$ where κ_v and κ_w are unknown constants in the interval (0,1) called tuning parameters. Note that if κ_v and κ_w were known, $d_1 \ldots d_t$, variance $\kappa_v V_t^*$, and covariance matrix $\kappa_w \mathbf{W}_t^*$ could be used to fit a SSM to obtain $\hat{d}_{t+3}$. Let SSPE be the sum of the squares of the prediction errors. Then SSPE is a function of κ_v and κ_w. These are estimated by minimizing

$$\text{SSPE} = \sum_{t=7}^{33} (\hat{d}_{t+3} - d_{t+3})^2$$

Once $\hat{\kappa}_v$ and $\hat{\kappa}_w$ have been obtained recalculate $\hat{d}_7 \ldots \hat{d}_{36}$ using the tuned variance $\hat{\kappa}_v V_t^*$ and tuned covariance matrix $\hat{\kappa}_w \mathbf{W}_t^*$. Variances $V_7^* \ldots V_{33}^*$ and covariance matrices $\mathbf{W}_7^* \ldots \mathbf{W}_{33}^*$ were estimated first using *SsfPack2.2* as done in the SSM, then the tuning parameters $\hat{\kappa}_v$ and $\hat{\kappa}_w$ were estimated using the routine *optim* in "R" (Ihaka and Gentleman 1996).

Figures 1 & 3 show the tuned SSM, SSM, and PF model predictions for the number of cancer deaths in Virginia for female breast cancer and testis cancer years 1978 through 2004. The tuned SSM has corrected some of the pronounced variations of the SSM. For testis cancer, the prediction for 1982 using the tuned SSM is -3, an improvement over the predicted -66 deaths of the SSM. However, the tuned SSM now

TABLE 1. Root mean square predictied error (RMSPE) for Virginia cancers using 3 prediction methods.

Site	RMSPE		
	PF	SSM	Tuned SSM
Brain and Other Nervous System	0.1002	0.1326	0.1194
Cervix Uteri	0.2803	0.3092	0.2738
Colon and Rectum	0.0735	0.1247	0.0788
Digestive System	0.0562	0.1187	0.0505
Female Breast	0.0961	0.0914	0.0786
Leukemia	0.1892	0.1597	0.1563
Liver and Intrahepatic Bile Duct	0.1827	0.2519	0.1802
Oral Cavity and Pharynx	0.1323	0.1400	0.1294
Stomach	0.1047	0.1088	0.1011
Testis	1.5748	2.4486	1.4515
Thyroid	0.3829	0.4198	0.3832

TABLE 2. Observed and predicted number of Virginian cancer deaths for 2004.

Site	Observed	PF	SSM	Tuned SSM
Brain and Other Nervous System	292	295	300	295
Cervix Uteri	76	106	97	105
Colon and Rectum	1285	1360	1378	1362
Digestive System	3102	3186	3214	3212
Female Breast	1059	1125	1109	1099
Leukemia	499	515	504	504
Liver and Intrahepatic Bile Duct	327	338	321	350
Oral Cavity and Pharynx	154	163	163	163
Stomach	248	303	303	303
Testis	5	5	4	-1
Thyroid	27	30	30	30

has 7 negative predictions which is still better than the PF model which has 9 negative predictions. The worst prediction for the tuned SSM is in year 1997 when the model predicts -6 testis cancer deaths.

DISCUSSION

Both the SSM and the tuned SSM are able to respond faster to local changes in the series of cancer deaths compared to the PF model as can be seen in predictions for Virginia female breast cancer deaths (Figure 1). But, both the predicted series from the SSM and the tuned SSM are more jagged than the PF model sometimes resulting in more unreasonable results. The tuned SSM is able to smooth some of the SSM's jaggedness, but still produces oscillating predicted series. In some cases, the tuned SSM is able to bring the predictions closer to the observed values.

Table 1 contains the RMSPEs using all 3 models for predictions from several Virginia cancer groups, years 1978 to 2004. The RMSPE is consistently smaller for

the tuned SSM compared to the untuned SSM. The SSM RMSPE is smaller than the PF model RMSPE for only female breast cancer and leukemia. These two cancers have smaller fluctuations in the observed series than the other cancer sites, allowing the SSM to perform better than the PF model. The more oscillatory series of the other cancer sites produce extreme fluctuations in the untuned SSM. The tuned SSM is able to smooth these fluctuations and perform better than the PF model for all but three of the cancer sites. For female breast cancer tuned SSM reduces the RMSPE by 18%. For leukemia tuned SSM reduces the RMSPE by 17%. However, for the brain and other nervous system cancers the PF model RMSPE is 16% smaller than the tuned SSM RMSPE.

Table 2 shows the observed and predicted values for several Virginia cancer sites for the year 2004. Notice for the cancers included in table 2, the predictions for cancers with smaller mortality counts are close if not identical for the 3 methods.

For Virginia's cancer mortality predictions the tuned SSM appears to perform better than the PF method when looking at the predicted series as a whole. This is because the tuned SSM is able to adapt quicker to changes in mortality trends; however this added sensitivity can sometimes cause unwanted results.

There is definite room for improvement in cancer mortality predictions. Both the SSM and tuned SSM assume the errors to be normally distributed. While this may not be a problem at the national level, small mortality counts at the state level and with some rarer cancers might cause this to be a problem. This is especially apparent with Virginia's testis cancer predictions. One could improve on this by assuming a different distribution on the errors, such as a Poisson distribution, and then using Dynamic Generalized Linear Models. Another suggested improvement would be to use different time-varying trend models for different cancers. But, this would require the researcher to choose the best model for each type of cancer. Yet another suggestion is to use a joinpoint model (Tiwari et al. 2004). Finally, Tiwari also suggested the use of preliminary mortality estimates in predictions. Research is ongoing to find the best method of cancer mortality prediction.

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