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EDITORIAL POLICY AND FORMAT

DARBAKER PRIZE

PENNSYLVANIA ACADEMY OF SCIENCE BOOKS
OVENBIRD NEST SITE SELECTION WITHIN A LARGE CONTIGUOUS FOREST IN EASTERN PENNSYLVANIA: MICROHABITAT CHARACTERISTICS AND NESTING DENSITY

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ABSTRACT

Since 1982, Ovenbird breeding populations have been monitored on two forest plots within a contiguous forest of greater than 10,000 ha at Hawk Mountain Sanctuary in southeastern Pennsylvania. On these two plots, Ovenbird territory densities have increased and are currently increasing between 1982 and 2000, with an increase in territory size of greater than 20% between 1991 and 1999. A third plot where surveys began later, the numbers of territories declined from 7.9 per 10-ha to 1.2 per 10-ha between 1991 and 1999 (Goodrich, unpublished data). In this study, we evaluate if Ovenbird nests sites with certain vegetation and microhabitat characteristics for their nests. That is, if there are any differences in territory density found within this eastern Pennsylvania contiguous forest. We examined the microhabitat and vegetative characteristics of 11 Ovenbird nests from the two long-term study plots, Owl’s Head and River of Rocks, together with 11 nearby random points in the plots (random-linked sites), and the random points in the study area (the less dense Visitor Center plots). We compared habitat variables using multiple ANOVA and least square means test. Significant variables were placed in a model to predict nest occurrence and the best predictive model comparing Visitor Center to nest sites and random-linked to nest sites was selected using AIC values. Nest site areas had a significantly greater percentage of vegetation cover, number of plant stems, and number of plant species than did either the random-linked or Visitor Center plots. The best models to predict nest occurrence included percent vegetation cover within higher density areas (i.e., Owl’s Head and River of Rock’s plots) and number of stems when comparing nests to lower density sites on the Visitor Center plot. Litter depth also was an important predictor of nest occurrence within nesting areas with nest sites. Our results suggest that microhabitat and vegetation characteristics can vary significantly within a contiguous forest and these differences influence Ovenbird nesting densities. Microhabitat differences within the Visitor Center site (e.g., percent cover, number of species) may be mediated in part by higher frequency of white-tailed deer, greater abundance of invasive species, or other factors associated with its location near a forest opening. Disturbance factors that limit ground cover vegetation extent and diversity may limit the distribution of this forest-interior nesting species even within large forest blocks.

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INTRODUCTION

Ovenbird (Seiurus aurocapilla) is a neotropical migrant passerine that nests on the ground in small, dome-shaped nests in the interior of large forests. Robbins et al. (1989) found the species nesting in small forest fragments ranging from 100-850 ha as well as larger forests. Studies have shown that the breeding success of Ovenbirds is significantly lower in smaller forest fragments (Porzelnio et al. 1993, Robinson et al. 1995, Goodrich et al. in prep). Giocomo et al. (in prep) found that Ovenbird territory density is significantly lower in forest fragments less than 100 ha in size. Reasons for these differences may vary. In some cases it may result from increased nest predation by species utilizing the forest edge (Zegers et al. 2000). In other regions, the increased level of brown-headed Cowbird parasitism (Molothrus ater) in fragments has been shown to cause forest bird declines (Robinson et al. 1995). Nesting territories in smaller fragments may also have reduced food supplies due to increased light reaching the forest floor (Burke and Nol 1998). Lower nestling densities of Ovenbirds may result if small forest fragments have inadequate habitat and food resources.

Long-term declines in Ovenbirds have been noted in a number of areas across their range, particularly in those areas most seriously affected by habitat fragmentation, such as Southern New England and the Cumberland Plateau (Sauer et al. 2005). Areas that still harbor abundant contiguous forest tracts such as Pennsylvania (Goodrich et al. 2002), are considered key regions for the long-term conservation of this forest-interior species. However, contiguous forest tracts in Eastern North America also may vary in habitat quality and suitability for forest interior birds. Among the threats to birds in large forests in Pennsylvania are over-browsing by burgeoning white-tailed deer (Odocoileus virginianus) populations (DeGraaf et al. 1991, Horsey et al. 2003), acid rain effects on vegetation health, soil ecology, and invertebrate population dynamics...
and habitat alteration through colonization by invasive species (Banik et al. 2002, Schein et al. 2003). At Hawk Mountain Sanctuary, Berks County, Pennsylvania, within a greater than 10,000 ha tract of contiguous forest in the central Appalachian Mountains, Ovenbirds have been monitored on two study plots, Owl's Head and River of Rocks, since 1982 (Pornelzi et al. 1993, Goodrich et al. 1998). The third plot, Visitor Center, was surveyed annually from 1991 through 1999. Between 1991 and 1999, Ovenbirds averaged 6.3 ± 1.1 territories/10 ha and 5.4 ± 1.3 territories/10 ha on Owl’s Head (OH) and River of Rocks (RO) plots. RO plot density increased non-significantly by 35% and 25% respectively (OH: r = 0.23, df = 1, p = 0.50; RO: r = 0.58, df = 1, p = 0.11) (Goodrich et al. 1998, Barber and Goodrich, in prep.). In contrast, on the nearby Visitor Center plot (VC), a 500 m × 100 m plot adjacent to a 5 ha opening, the number of territories declined from an average of 7.7 territories/10 ha to only 1.12 territories/10 ha in 1999, a decline of 85% (Pearson correlation, r = -0.89, p = 0.001, n = 9). Nesting success on the Owl’s Head and River of Rocks plots has remained consistently high in the last 20 years, and significantly higher than near-forest fragments suggesting that recruitment is not an issue within this forest landscape (Pornelzi et al. 1993, Goodrich et al. in prep.). Ovenbird territory density has been shown to decline within forest adjacent to a clearing during the three years after forest cutting (e.g., Wainaldorfer et al. 2006), however, the observing was established in the mid-1970s, so decline in Ovenbird use in response to a new opening should have been detected earlier. In this paper we examine if Ovenbirds select their nest sites within a contiguous forest based on microhabitat characteristics or if they place them at random, and if microhabitat differences may explain, in part, the significantly reduced densities of Ovenbirds observed in some areas. We investigate this question by quantifying the vegetative structure and other microhabitat characteristics near nest sites on the plots where densities increased, Ovenbirds and River of Rocks, and comparing random points paired with each nest site on the two sites where density increased and also with random points located on the nearby Visitor Center plot where nesting densities have declined.

METHODS

**Study Area.** The study was conducted at Hawk Mountain Sanctuary (HMS) in Berks County, Pennsylvania (40° 38’N and 75° 59’W). The 972 ha sanctuary is located within a larger than 100,000 ha forest on the Kittatinny Ridge of the central Appalachians in southeastern Pennsylvania. Our first plot, known as Owl’s Head, is a 19.4 ha, 490 × 400 m rectangle on a ridge-top 408-448 m in elevation and heavily forested. The canopy is comprised mostly of chestnut oak (Quercus prinus) and red maple (Acer rubrum), while the understory is made up of black gum (Nyssa sylvatica) and sweet fern (Comptonia peregrina). The shrub and ground cover layer is composed of huckleberry (Gaylussacia baccata), sheep laurel (Kalmia angustifolia), lobrewsh blueberry (Vaccinium pallidum), sweet fern (Comptonia peregrina), sweet fern (Vaccinium angustifolium). The second plot, River of Rocks, is a 1.69 ha, 430 × 400 m rectangle on an eastward facing rocky slope 265 to 347 m in elevation. It is also dominated by chestnut oak, mostly red maple, but also sweetgum and sweet fern (Bendena lentis) make up a larger portion of the canopy than on Owl’s Head (Steekel 1998). Black gum and sassafras still dominate the understory, although mountain laurel (Kalmia latifolia) is found in dense stands in certain areas on the plot. The shrub layer is largely similar to that found on Owl’s Head (Goodrich et al. 1998). The Visitor Center plot, a 500 m × 100 m approximately 396 m in elevation. The vegetation is similar to that on the Owl’s Head plot. However, Visitor Center is adjacent to the HMS Visitor Center and much of the plot lies within 100 m of a building, parking lot, or small clearing. This plot was smaller than the other two plots as it was designed to be adjacent to the opening. All three plots lie within 1 km of each other.

**Survey and Nest Search Protocol.** Beginning in early May 2003, both the Owl’s Head and River of Rocks plots were surveyed almost daily as either part of a continuing Breeding Bird Census conducted annually since 1982 (Ralph et al. 1992, in prep.), or a separate Ovenbird nesting biology (e.g., Pornelzi et al. 1993). Surveys were conducted between dawn and 10 am EST on each plot by systematically walking 30 meter grid lines across each study site. During these surveys, all Ovenbirds sighted or heard were marked on plot maps using the spot-mapping technique and sightings of previously color-banded males were mapped along with any associated mate. All color-marked males were followed for 10 or more minutes each to detect behavior by male or female suggesting nesting activity. Any nests located during surveys were flagged so they could be relocated the next day. The same survey plot, which had been eliminated from the long-term study in 1999, was surveyed three times in 2003 for Ovenbird use during June and early July. Locations of singing or sighted birds were mapped and tallied following standard Breeding Bird Census instructions to determine the number of territories present on each plot (Ralph et al. 1993).

**Vegetation Survey Protocol.** Vegetation characteristics were measured at each of the nests in mid to late July 2003, after the nestlings had fledged. Sampling was conducted after fledging to avoid disturbing the nests. As many of the plant species found on the floor in this forest were woody perennials, we assumed that any relative differences among the sites found in July would be representative of differences present in early May when most of the birds return and select nest sites. Canopy and herb layer species, Canopy and herb layer species, tree and other forest characteristics were not measured as our purpose was to compare the microhabitat at nest sites to other forest sites with similar vegetation, not within the same species list.

**RESULTS**

**Breeding Densities and Nest Sites.** Territories were not checked on Visitor Center from 2000 to 2002, however in 2003 the density of Ovenbirds remained low in comparison to other study areas, e.g. there were 9.7 territories/10 ha on the Owl’s Head plot, 5.6 territories/10 ha on the River of Rocks plot, and 2.2 territories/10 ha on the Visitor Center plot. In 1999 territory density was similarly low on the Visitor Center as compared to the other two sites. Because the pattern of lower density in 2003 was similar to 1999 (1.1 territories/10 ha) we assumed the lower density was not an anomaly. Eleven nests were located on the Owl’s Head and River of Rocks plots (e.g., 72% of 2003 nesting pairs on the plots). Thus, vegetation cover and site characteristics were compared between 11 nests and 11 random sites within the two sites, the three density plots, and the two sites within the lower density plot, Visitor Center. Habitats Analyses. A total of 22 plant species were recorded in the 1 m² plots with 0 to 3 unknown species recorded per plot. The percentage of vegetation cover significantly differed among the three plots (Table 1) (F = 5.453, df = 2, p = 0.009). Cover percent around nests ranged from 10 to 100 percent with an average of 62.6% per nest (Table 1). Bonferroni post-hoc pair-wise comparisons

| Table 1. Microhabitat measurements of Ovenbird nests and random plots on Owl’s Head, River of Rocks, and Visitor Center plots at Hawk Mountain Sanctuary, 2003 (mean ± standard error); **(Denotes value significantly greater than other site values (p < 0.05).)** |

<table>
<thead>
<tr>
<th>Site</th>
<th>Distance to Edge (m)</th>
<th>Litter Depth (cm)</th>
<th>% Vegetation Coverage**</th>
<th>Number of Blueberry Stems**</th>
<th>Number of Blueberry Stems**</th>
<th>Number of Blueberry Stems**</th>
<th>Number of Rye Grass Stems**</th>
<th>Number of Rye Grass Stems**</th>
<th>Number of Tree Seedlings**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nests (n = 11)</td>
<td>51.25</td>
<td>13.35</td>
<td>45.5</td>
<td>0.47</td>
<td>62.2</td>
<td>25.3</td>
<td>38.64</td>
<td>48.88</td>
<td>19.27</td>
</tr>
<tr>
<td>Random 1 (n = 11)</td>
<td>57.00</td>
<td>10.65</td>
<td>3.18</td>
<td>0.42</td>
<td>33.6</td>
<td>9.7</td>
<td>32.46</td>
<td>64.9</td>
<td>13.28</td>
</tr>
<tr>
<td>Random 2 (n = 11)</td>
<td>43.25</td>
<td>10.31</td>
<td>3.54</td>
<td>0.48</td>
<td>26.7</td>
<td>6.74</td>
<td>22.5</td>
<td>2.68</td>
<td>11.92</td>
</tr>
</tbody>
</table>

**Denotes significant difference found among the three plots at p<0.05 level.**
revealed that vegetation cover was significantly higher at nest sites than at the random points in the Visior Center plot (mean difference = 36.06%, p = 0.011, df = 31) and cover also was higher at nest sites compared to the random-linked sites (mean difference = 29.09%, p = 0.057, df = 31). However, there was no significant difference between the random-linked and random Visitor Center sites (mean difference = 6.97%, p > 0.05). The average number of plant stems per plot varied significantly among the three samples (r = 0.397, F = 2.894, p = 0.07, df = 34; Table 1). Stem density at nest sites was higher than at Visitor Center points (Bonferroni pairwise mean difference = 16.156, df = 31, p = 0.07), but was not greater than stem density at the random-linked sites (pairwise mean difference = 6.182, df = 31, p = 0.65) (Table 1). The random-linked sites had more stems, but there was no significant difference between them and the Visitor Center sites (p = 0.32).

The average number of plant species per plot also varied significantly among the three sites (r = 0.438, F = 3.678, p = 0.037, df = 31) (Table 1). Post hoc Bonferroni pairwise comparisons revealed that species diversity was greater at nest sites than at Visitor Center sites (mean difference = 2.144, df = 31, p = 0.031), but not at the random-linked sites (p = 0.974), and there was no significant difference between random-linked and Visitor Center sites (p = 0.323).

Litter depth, basal vegetation, and number of blueberry stems (Vaccinium sp.) were higher at nest sites compared to random points but the differences were not significant (Table 1). No other measurements exhibited significant differences between any of the sites (p > 0.1), including percent litter cover, distance to the nearest edge or trail, percent bare ground, basal area, the abundance of any of the individual species (e.g. red maple, mountain laurel, etc.), distance to nearest tree in the four cardinal directions, slope, and aspect. Bonferroni posthoc pairwise comparisons were conducted on all insignificant habitat variables although none of the pair wise comparisons were significant (p > 0.10).

The average percent nest concealment for the 11 nests was 55% and did not differ between the two plots with nests (t-test, p = 0.61). Black gum was the most frequent tree on the three study plots comprising 42% of all trees, followed by chestnut oak with 26%, red maple with 17%, and red oak with 10%. There was no difference in the frequency of these trees among the three plot sites.

**Comparison of Variables.** The number of stems, number of species, percent vegetation cover, litter depth, and basal area, were included in our set of competing logistic regression models to determine which variable or combination of variables was the best predictor of Ovenbird nest presence. We evaluated litter depth as a predictor of Ovenbird nest sites because it was marginally significant and has been shown to be important in other studies of Ovenbird nest sites (Burke and Neff 1998). Because of the small sample size (n = 34 total points sampled), we compared nest sites to the random-linked and Visitor Center points separately.

When comparing nests and Visitor Center sites, the number of stems and percent vegetation cover were both important predictors of nest presence, with Akaike weights of 0.411 and 0.336 respectively (Table 2). Of the two, the number of stems seemed most important. The probability of a nest being present (P) was modeled as Log (odds) = -4.4179 + 0.1500 * (number of stems) (P < 0.05) for both the intercept and the number of stems, (standard error of intercept = 2.1528, standard error of number of stems = 0.0738). According to this model, the probability of an Ovenbird nest being present on a plot with <15 stems was <11% (Figure 1). But the probability of a nest being present on a plot with >38 stems was >80%. The percent vegetation cover model was also useful in modeling nest presence with this equation: Log (odds) = -2.2266 + 0.4862*percent vegetation cover” (P < 0.05 for both intercept and the percent cover, standard error of intercept = 0.9990, Standard error of % vegetation = 0.1984) (Figure 2).

For nest plots versus random-linked plots Akaike weights suggested that percent vegetation cover and litter depth were the two most important variables (0.3445 and 0.2417 Akaike weights respectively, Table 3). The best predictor model included only percent vegetation cover: Log (odds) = -1.7205 + 0.3588 *percent vegetation (P < 0.08 for the intercept and P < 0.04 for the percent vegetation; Standard error of intercept = 0.9554, standard error of percent vegetation = 0.1727). Using this equation, the probability of an ovenbird nesting in a 1 m² plot when comparing nest sites to random linked sites (Log (odds) = -2.2266 + 0.4862* (vegetation%)).
our results (Horsley et al. 2003). The Visitor Center plot is within 100 m of the Visitor Center and its parking facilities, while the other two plots are both >1 km away from this opening, and deer may be more frequent in this area.

Another possible impact in the Visitor Center area of the forest is the invasion of non-native species along openings. Non-native plants, such as stilt grass (Microstegium vimineum), have begun to enter much of the forest interior along drainage swales adjacent to the Visitor Center and are altering the composition of the nearby forest ground cover (and its associated invertebrate populations). Non-native earthworms also have been invading the Hawk Mountain forest in recent years, particularly adjacent to disturbed areas (Muerz, J., pers. comm.). Recent research suggests that non-native earthworms may reduce the leaf litter mass which may affect both nest site suitability and prey availability as the worms appear to deplete the forest floor invertebrate population and reduce plant species richness (Holdsworth et al. 2007, Muerz, J., pers. comm.) Because Ovenbirds feed predominantly on forest floor invertebrates (Van Horn and Donovan 1994), non-native species that cause reduction in invertebrate densities could indirectly reduce the quality of nesting habitat available. A final consideration is ground predators. Just as with deer, there may be more-sized medium- and small mammals near the Visitor Center plot due to the plot's proximity to the HMS Visitor center and its parking facilities, and their bird feeding stations. Studies on other ground-nesting birds have shown greater nest densities and greater nest survivorship in areas with larger small mammal numbers (Monton 2005, Schmitt et al. 2006).

Microhabitat differences appear to have important consequences for patterns of nest density in forest-nesting birds even within large areas of contiguous forest. Burke and Nol (1998) found that pairing success on small forest fragments was at times 0% while on the largest fragments it reached 100%. They attribute this drastic difference to the nest site microhabitat characteristics that females prefer, suggesting that females choose sites with deep litter and other characteristics that will increase their reproductive success. Coupled with our findings, this suggests that there may be certain microhabitat features that are often absent or that render nesting attempts. As suggested by Burke and Nol (1998), these characteristics may be indicative of habitat quality for invertebrate prey populations, but they may also be important for nest concealment and predator avoidance. In contrast, Van Horn and Donovan (1994) report little is known about nest site selection in Ovenbirds but they nest “in areas where the forest floor is open and shrubs are sparse”; they also note some nests are placed in “moderately dense herbaceous vegetation”. Results of this study suggest Ovenbirds may prefer to place their nests in moderate dense cover and selection of sites in open areas may be a response to a lack of available cover or other aspects over-riding this preference such as litter depth.

This study highlights the need for a detailed understanding of the microhabitat characteristics needed for a healthy species population in conservation planning, not merely the overall habitat type or patch size most frequently used.

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LITERATURE CITED


TARDIGRades of NORTH AMERICA: INFLUENCE OF SUBSTRATE ON HABITAT SELECTION

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ABSTRACT

The patterns of habitat (moss or lichen) selection have been elusive for tardigrades. Samples of habitat were collected from ten different substrates (species of tree), the nematodes, rotifers, and tardigrades counted, and their distribution, density, and patterns of association analyzed in suburban Philadelphia. All three taxa were found more frequently than expected further from the roads while none showed a preference for height. Rotifers were positively associated with the moss habitat while nematodes and tardigrades were evenly distributed. All three taxa favored the Dogwood (Cornus floridana) as a substrate while each taxon was negatively associated with other substrates (trees). This is the first report of tardigrades from Pennsylvania; 546 specimens from the following eight species are recorded: Milnesium tardigradum, Macrobiotus areolatus, Macrobiothus harzwothi, Macrobiotus hufelandi, Macrobiotus islandicus, Manibiotus intermedius, Ramazzottius oberhaeueri, and Icthyaulax sp. The four most numerous species were each positively associated with different combinations of location, height, habitat, and substrate. Tardigrades were found more frequently than expected in habitats on angiosperm substrates. Evidence was found for association, positive or negative, between each substrate and at least one species of tardigrades. A range of pH values was identified among the different substrates. The tardigrades Milnesium tardigradum and Ramazzottius oberhaeueri were associated with higher pH, while Manibiotus intermedius preferred the more acidic substrates, and Macrobiotus hufelandi was found over the widest range of pH. These patterns suggest the possibility for the development of micro-invertebrates as bio-indicators for habitat quality analysis.

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INTRODUCTION

The animals of the phylum Tardigrada remain a little known, little studied group (Kinchin, 1994). The ecological requirements of tardigrades are equally unknown, and although often abundant, the contribution of water bears to the biodiversity of the ecosystem is under documented. This lack of basic biological information may have excluded tardigrades from ecological and environmental studies. Of the more than 700 described species of limno-terrestrial tardigrades only about 125 have been recorded from North America (McIntire, 1994). There are no records of tardigrades from Pennsylvania (Miller, 1997). Yet, in other regions they are often common in the aquatic habitat formed by water trapped by the leaves of mosses and the thalli of lichens. Nelson (1975) stated that, "No correlation was noted between the various species of tardigrades and the species of moss. In general, tardigrades inhabited a variety of moss species." Ramazzotti & Maucci (1983) and Kotham & Cross (1991) both suggested that moss animals do not specialize in particular moss species. Meyer (2006a) was also not able to report a significant association between species of tardigrade and habitat in his extensive study in Florida. In contrast, Kummer and Meglinski (1969) reported that tardigrades on Iowa trees had a relatively high frequency index for height, habitat, and substrate. Senèdra (1982) found fewer species at urban sites than at suburban sites and suggested a link between air quality and tardigrade diversity. Miller et al. (1996) demonstrated that in the simpler ecosystem of Antarctica some relationships existed between habitats and species of tardigrades. Miller et al. (2001) again identified associations between species of tardigrades and their habitats.

Meininger et al. (1985) measured the air pollution around Cincinnati, Ohio and reported that air quality had a high correlation with lichens, humidity, pH, and tardigrade populations. In Alaska, Meininger and Spratt (1988) studied the impact of calcium carbonate dust from a road on the pH of the surrounding sphagnum moss. The pH of the moss declined and the composition of the tardigrade population changed with increased distance from the road.

Dastych (1988) reported that Polish tardigrade diversity changed with increasing acidity. Steiner (1994a) stated that tardigrades are affected by many interrelated biotic and abiotic factors, such as moisture, location, height, temperature, and substrate. He further observed that mires from urban locations have significantly higher pH than do those from rural sites. Steiner (1995) concluded that abiotic factors are more important than the species of moss and that the acidic nature of the habitat may determine community structure, but conceded that, "knowledge about terrestrial invertebrates as indices of environmental quality is alarmingly poor." Because two of the major tardigrade habitats (mosses and lichens) are found in abundance in Pennsylvania, this study was undertaken to confirm the presence of the phylum and establish an initial diversity for the state. In study, the study afforded the opportunity to test the hypothesis that the substrate (species of trees) upon which the habitat (moss or lichen) is found does not influence the distribution, density, or diversity of micro-invertebrates, especially the tardigrade.

MATERIALS AND METHODS

The study area was the 40-acre campus of Chestnut Hill College in west suburban Philadelphia, PA (40° 05' 11.01" N, 75° 13' 37.55" W). The campus has over a thousand trees of 50 identified species (pers. comm. Ed LaFeroy). A matrix of ten specimens of ten different trees was chosen as the experimental design. Two samples were collected from each tree, one at the base and one two and a half meters up the trunk. A five centimeter-square sample of moss or lichen habitat was scraped from the substrate tree into a paper bag and labeled. Location was recorded with a Garmin GPS 12 and each tree digitally imaged for reference to the Master Landscaping Plan. Each sample was soaked for 24 hours in a small dish of spring water. Three sub-samples were inspected at 30-power with a dissecting microscope and reflected light. Three plasmodia of animals (tardigrades, nematodes, and rotifers) were counted. The tardigrades were removed with an Irwin loop and mounted on slides in Hoyer's media under a glass cover slip (Miller, 1997). The tardigrades were identified to species using the keys in Ramazzotti & Maucci (1983) and Nelson (1991).

Distribution was assessed by the occurrence of the taxa in three zones (Figure 1). Zone A was near the roads that edged the campus. Zone B was the hill upon which most of the campus buildings were located. Zone C was the flood plain of the Wissahickon Creek. Density was recorded as the number of animals per sample. Diversity, the number of

Figure 1. Chestnut Hill College Campus, Philadelphia, PA, USA. Large letters denote Zones; small letters denote tree species.
species in a sample, was limited to tardiagradae because rotifers and nematodes were not identified to species. Acid-
ity (pH) of each sample was determined by colorimetric
chemical reactions after treatment with pH determining
reagents in a Lachat Soil Testing Kit (Tucker, 1994).
Because of the small size of the study area, and the uni-
formity of the prevailing conditions, even distribution, diver-
sity and density was expected. Microsoft Excel was used to
calculate Chi Square ($\chi^2$) (Bowker, Cohen, and Jarvis, 1998)
for the difference between the observed and expected values.
Chi-Square is a one-tailed test that ignores any other rela-
tionship except the magnitude of the difference. We coded
the association significantly greater than expected
– Association significantly less than expected
- Association not present

RESULTS

The ten substrates were the gymnosperms Eastern Hem-
lock (Tsuga Canadensis), Eastern White Pine (Pinus strobus), Sawara Cypress (Chamaecyparis pisifera), and Norway Spruce (Picea abies) and the angiosperms Red Oak
(Quercus rubrum), Norway Maple (Acer platanoides), Sugar
Maple (Acer saccharum), Japanese Maple (Acer palmatum),
Dogwood (Cornus florida), and Crabapple (Malus sp.).
(Table 1). Two hundred habitat samples (161 lichen and 39
mosaic) were collected during the summer of 2001. The
lichens were the greenish Flavoparmelia sp. and the grayish
Pseudoparmelia sp.; the mosses were not identified.
The samples yielded 5,681 micro-invertebrates: 4,292
rotifers, 843 nematodes, and 546 tardiagradae. Rotifers
occurred in 169 samples, nematodes in 103 samples, and
tardiagradae in 99. The distribution by zone, height, habitat,
and substrate is presented in Table 1.

Only rotifers occurred more frequently than expected in
zone A. All three taxa occurred less frequently in zone B
and more frequently in zone C. All three micro-invertebrates
were represented as expected at both heights. Rotifers were
more frequent in mosaics and less frequent in lichens. Nema-
todes and tardiagradae showed no preference for habitat
(Table 1).

The four positive taxa-substrate associations were with
angiosperms while five of seven negative associations were
with gymnosperms. The Dogwood (C. florida) was the only
substrate on which all three taxa occurred more frequently
than expected. Tardiagradae also favored the Sugar Maple
(A. saccharum) as a substrate. The least favored substrates
were

the Eastern White Pine (P. strobus) where both nematodes
and rotifers were numerically less numerous and the Norway Spruce (P. abies) where nematodes and tardiagradae were less numerous (Table 1).

Of the 546 tardiagradae, 464 were in a life stage that could be
identified to species. Eight species from two orders and
five genera were identified as follows: 171 Milsacidium tardi-
gradum Doyère, 1840, 22 Macrobrotus areolatus Murray, 1907, one Macrobrotus horribilis Murray, 1907, 18 Macrobrotus hafeldani Schultze, 1839, nine Macrobrotus islandicus Richers, 1904, 56 Microbiobius intermedius (Prime, 1889), 74 Ramazzottius oberhaeuseri (Doyère, 1840), and
three Leucopis sp.

Tardiagradae species richness was eight and the Simpson’s
Index of Diversity was 0.75. The maximum diversity was
discussion

The study confirmed the presence of phylum Tardiagradae
in Pennsylvania. This first record adds a new phylum and
eight species to the biodiversity list for the state.
The large number of micro-invertebrates present and their
broad dispersal throughout the small study area demonstrat-
et that their ability to colonize a local habitat was not a
limitation and the expectation of even distribution, density,
and diversity was validated. Thus, we concluded that
observed differences were an expressed result of conditions.
The distributional patterns suggest each phylum has differ-
ent requirements. The positive association for all three phyla
for zone C, furthest from the road, suggests that each taxon
may be sensitive to the air quality as suggested by Steiner
(1994a, 1994b, 1994c, 1995), Semmens (1982), and Hohi et al.
(2001). The uniformly negative association with zone B sug-
gests that habitats affect the quality of the habitat.
None of the taxa showed a preference for height. It was
observed that the sampling height was a vertical part of the
substrate and may be an expression of habitat rather than
taxa selection.

All phyla were represented on all substrates but not uni-
formly. Gymnosperms were less desirable than expected
whereas few angiosperms were uninhabited (Table 1). All three phyla found the conditions provided by the habitats on
Dogwood (C. florida) substrate with its higher pH to be
acceptable, whereas two of the taxa found the Eastern White
Pine (P. strobus) with its higher acidity (lower pH) to be
the least favorable. Tardiagradae found Sugar Maple (A. sacca-
rum) to be a favorable substrate but nematodes did not
(Table 1). These different results suggest that the substrate
contributes to the chemistry of the intestinal habitat used
by these taxa.

More than half of the tardiagradae associations measured
expressed significant shifts from the expected values of our
pH (higher acidity). Macrobrotus hafeldani was found over
the widest range of pH values (Table 2).


discussion
<table>
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<tr>
<th>Species</th>
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<th>pH 6.8</th>
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**ACKNOWLEDGEMENTS**

We are grateful to Chestnut Hill College Grounds Keeper, Edward J. Lafferty for sharing his knowledge and records of the trees of the campus. We also wish to express our appreciation to the reviewers who made several suggestions that have improved the manuscript.

**LITERATURE CITED**


SUMMER BATS OF POTTER AND McKean COUNTIES, PENNSYLVANIA AND ADJACENT CATTARAUGUS COUNTY, NEW YORK

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ABSTRACT

Five species of bats (n = 666) were caught: 47 big brown bats (Eptesicus fuscus), 20 red bats (Lasiusurus borealis), 4 hoary bats (Lasiusurus cinereus), 382 little brown myotis (Myotis lucifugus), and 211 northern myotis (Myotis septentrionalis). Catch was 12.1 bats/net site (SD = 16.0) and 2.9 bats/net night (SD = 2.4). At least one bat was captured at every net site, but at three sites only a single bat was caught. The greatest catch per site was 87, 67, and 34 (2 sites) bats. Species richness was highest at two sites where five species were caught; 2.2±1.1 species were caught per site and MacArthur's diversity index was 2.29. Evidence of reproduction was obtained for all species. Significantly more little brown myotis were caught late in the evening (χ^2 = 10.28; P = 0.001), while the greatest catch of northern myotis was early in the evening (χ^2 = 32.05; P < 0.001). More big brown bats (χ^2 = 57.28; P < 0.001), little brown myotis (χ^2 = 382.27; P < 0.001), and northern myotis (χ^2 = 20.66; P < 0.001) were caught late than early, in the season. Little brown myotis were most frequently captured in riparian habitat (χ^2 = 45.79, P < 0.001) while northern myotis were more often in uplands (χ^2 = 22.53, P < 0.001). Similarities and differences in species diversity, relative abundance, reproductive condition and relative abundance of the sexes, periods of night time and seasonal activity, and use of habitat between this and other studies indicate that there are many aspects of the ecology of these species that we have yet to understand.


INTRODUCTION

Eleven species of bats occur in Pennsylvania (Doutt et al. 1977; Merriam 1987; Whitaker and Hamilton 1998): Little brown myotis (Myotis lucifugus), northern myotis (Myotis septentrionalis), Indiana bat (Myotis sodalis), small-footed myotis (Myotis leibii), big brown bat (Eptesicus fuscus), evening bat (Nycticeius humeralis), eastern pipistrelle (Pipistrellus subflavus), eastern red bat (Lasiusurus borealis),}

hoary bat (Lasiusurus cinereus), Seminole bat (Lasiusurus seminolus) and silver-haired bat (Lasionycteris noctivagans). The Seminole bat and evening bat are not known from north-central Pennsylvania, including the project area. Although all these species are widespread in the eastern United States, relatively littile information is available about their distribution and abundance in Pennsylvania.

The purpose of this paper is to provide documentation of species of bats caught in northern Potter and McKean counties, Pennsylvania and adjacent Cattaraugus County, New York. Their relative abundance, evidence of reproduction and relative abundance of the sexes, periods of night time activity, relative abundance through the summer season, and habitat use were recorded. As identified by Yahner (2003), it is hoped that these data will contribute to understanding of the abundance and distribution of these species and development of sound conservation strategies for bats in Pennsylvania. These data are also compared to recent similar studies within forests of the eastern United States, including Ravnena Training and Logistics Site in north-central Ohio (Brack and Dufey 2006), Camp Dawson Collective Training Area in northern West Virginia (Brack et al. 2005), Crane Division, Naval Surface Warfare Center and Hoosier Nation Forest in south-central Indiana (Brack and Whitter 2004; Brack et al. 2004), and Ft. Leonardwood, in extreme eastern Kansas (Brack et al. 2007). Because numerous references will be made to these studies, they will for brevity be referred to hereafter as Ravnena, Camp Dawson, Crane, HNF, and Ft. Leonardwood.

MATERIALS AND METHODS

Study Area.—Studies were completed in northern Potter and McKean counties, Pennsylvania and in adjacent Cattaraugus County, New York during summer 2005 (Fig. 1). Most work was in the Glaciated High Plateau, although a small amount was in the Deep Valleys Section, also in the Appalachian Plateau Physiographic Province (PDCNR 2000). The Appalachian Plateau covers over one-half of Pennsylvania and is characterized by steep slopes interspersed with gently sloping plateau remnants, and numerous streams. The Glaciated High Plateau Section consists of broad to narrow, rounded to relatively flat, elongate uplands separated from the Glaciated Low Plateau Section by a steep-sloped, well defined escarpment (PDCNR 2000).
LOCAL RELIEF is low to high and underlyig rocks are sandstone, siltstone, shale, and conglomerate. The Deep Valleys Section has deep, steep-sided valleys separated by narrow, flat to sloping uplands (PDENR 2000). Relief between valleys and peaks can be x>300 m. The slope in most valleys is fairly uniform, but some have a large-scale, stair-step appearance from differential erosion of layers of sandstones and shales.

Braun (1950) described the forest association in the project area as the Allegheny Section of the Northern Appalachian Highland Division of the Hemlock-White Pine Northern Hardwood Region. Most of the project area lies within the unglaciated portion of the Allegheny, although the eastern sides cross into glaciated areas. Braun (1950) considered the natural forests of these glaciated and unglaciated areas as quite similar, with deciduous (Tsuga canadensis), beech (Fagus grandifolia), and sugar maple (Acer saccharum) as the most common canopy species, followed by black cherry (Prunus serotina), sweet and yellow birch (Betula lenta and B. lutea), red maple (A. rubrum), and white ash (Fraxinus americana). Following Braun (1950), Fike (1999) described a similar Hemlock (White Pine) Northern Hardwood forest association. However, Braun (1950) found forests in uplands so modified by man that it rarely bore any resemblance to the original cover type. An unacceptably variable abundance of dominant species (listing up to 3) was made at each site. It does not have any of the three species listed by Braun (1950) as the most common canopy species, 21 sites had one, 19 had two, and only 1 site had all three.

Captured adult males were caught during May and June, June and November, and June and July. Evidence of reproduction, juveniles or pregnant, lactating, or post-lactating females, was obtained for all five species captured. Notably, no reproductive female red bats were caught, although juveniles were captured. Chi-square tests indicated that the catch of adult male eastern red bats, little brown myotis, northern myotis, and all species combined, was greater than the catch of reproductive females (Table 1). Capture of at least three reproductive individuals (females and juveniles) indicated that maternity colonies of big brown bats were near 5 sites, of little brown myotis were near 17 sites, and of northern myotis near 8 sites. Little brown myotis were most frequently captured in riparian habitat (χ² = 45.79, P < 0.001) while northern myotis were caught disproportionately often in uplands (χ² = 22.53, P < 0.001). The rate of capture for over 5 hours of sampling differed significantly for the little brown myotis, northern myotis, and for all species combined (Table 2). Disproportionately, more little brown myotis were caught late in the evening, while the greatest catch of northern myotis was early in the evening (Fig. 2). Seasonal differences also occurred, with more big brown bats, little brown myotis, northern myotis, and all species combined captured later, than early, in the season (Table 3).

DISCUSSION

Although nine species of bats are considered resident in northwestern and central Pennsylvania and southeastern New York (Richmond and Rodman 1949; Rodman 1951; Doutt et al. 1977; Merritt 1987; Whitaker and Hamilton 1998), only five were caught. However, the remaining four species are rare or uncommon. No federally endangered Indiana bats were caught. Silver-haired bats are most likely

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<table>
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<th>Species</th>
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<th>PL</th>
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<th>Escape</th>
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<td>17</td>
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</tbody>
</table>

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Table 1. Captures of adult males, pregnant (P), lactating (L), post-lactating (PL) females, and juvenile (Juv) bats. Bats identified to species but which escaped before sex and reproductive data were collected are noted. A Chi-square test of equality of catch by adult male and reproductive females is provided by species.

Table 2. Number of 55 act sites where bats were caught, capture during each of five 1-hour periods (T1-T5) of netting beginning at dusk, and Chi-square analysis of the frequency of catch across the five periods.

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Figures and tables are placeholders for actual content that would be included in the journal article.
to be caught as migrants, during spring and autumn. Published records of small brown trout are largely from winter hibernacula surveys and predominantly from south of the project area in more montane terrain (Douet et al. 1977, Merritt 1987). In summer the species apparently roots in vertical cracks of exposed cliff faces (Craig Stihl, unpublished data). Neither Rosland (1951) nor Rich mond and Rosland (1949) reported the species from north- central or southwestern Pennsylvania, respectively. In contrast, although we did not catch eastern pipistrelles, Merritt (1987) considered the species common across the state, and both Rosland (1951) and Richmond and Rosland (1949) reported specimens from northeastern and northwest ern Pennsylvania.

During summer studies at the entrance to Aisken Cave, in Mifflin County to the southeast, Hall and Brenner (1968) also caught five in much different proportions: 1,060 little brown myotis, 175 northern myotis, 3 small-footed myotis, 17 eastern pipistrelle, and 7 big brown bats. However, use of caves in summer by bats may vary dramatically from use of woodlands. For example, bats may use caves for night roost between foraging bouts. Whittaker and Brock (2002) found that male, but not female, Indianas was often found in summer at caves as serve as winter hibernacula.

In comparison to other studies in wooded habitats of the eastern United States, the rate of bat capture in this study was greater than in previous studies (1977), being similar to T. Leavenworth, Kansas (Table 4) (Brock et al. 2007). Big brown bat.—The big brown bat was the third most common of the five species captured. The capture of big brown bats was similar across the five hourly capture peri ods. In contrast, capture was greater early in the evening for studies at Ravenna, northern Indiana (Brock 1985), and southcentral Michigan (Brock et al. 1984), when insects are most abundant (Brock and LaVal 1983). In the present study, the catch of big brown bats, considering adults and juveniles together and adults alone, was greater late in the season. Similarly, at Ravenna more adult big brown bats were caught late in the season. Comparable numbers of males and reproductive females were caught, although captures of reproductive females and juveniles were concentrated in five areas, indicating maternity colonies were nearby. The capture of adult males appeared to be more dispersed. Brock et al. (2002) found that females were more common than males at lower elevations in Pennsylvania, and on HNF, males were more common than females.

The big brown bat is often considered a generalist in the type of habitats frequented (Duchamp et al. 2004), which may help explain its wide geographic distribution and cap ture at many project locations. However, capture was dis proportionately high at riparian capture sites, as they were on HNF and St. Leavenworth. This species often eats heavily in the summer, as identified by Merritt (1987) and Agosta (2003). Ohio, (Bruck and Finney 1987), and Indiana (Whittaker 1995; Bruck and Whittaker 2004). Insects eaten often include forest pests such as the Asiatic oak weevils (Cyrtopertha cuneata) and agricultural pests such as the spotted cucumber beetles (Diabrotica undecimpunctata) (Whittaker 1995; Bruck and Whittaker 2004).

Eastern red bat.—The eastern red bat is a common summer resident in Indiana, often found along the eastern pipistrelle and in other parts of Pennsylvania, and uses a variety of woodland habitats. Red bats feed on a variety of insects, but moths often form much of the bat (Bruck 1983; Bruck and Finney 1987; Whittaker 1972; Whittaker et al. 1997), reflective of the woodland habi tats they occupy. In the present study, it was caught at 20% of sample sites. In contrast, in southcentral Pennsylvania's Ridge and Valley Region, which is less agricultural, Hart et al. (1993) reported red bats at 48.5% of sites netted and echolocation calls were detected at 53.8% of sample sites. The red bat is a seasonal migrant, and is likely absent for more months (Whittaker and Hamilton 1998; Walters et al. 2006).

The catch of adult eastern red bats was greater than the catch of reproductive females, similar to Camp Dawson, but in contrast to HNF. Differences in sex ratios of red bats have been attributed to migratory patterns (LaVal and LaVal 1979), but in West Virginia, Bruck et al. (2002) found an inverse relationship between reproductive females and elevation; higher elevations are cooler, wetter, and have more variable temperatures. Ford et al. (2001), looking at museum specimens, found that male eastern red bats dominated in the Appalachian Highlands where mean monthly temperatur e in June fell below 28.5°C.

The catch of eastern red bats was insufficient to test for even ness of catch over the evening sample period, but at Ravenna, Clermont County areas (Bruck and Finney 1987), Crone, and southern Michigan (Brack et al. 1984), the catch of eastern red bats was not concentrated in any portion of the night.

Table 4. Capture success during the present study compared to similar studies in woodland habitats in the eastern and midwestern United States, Bat Net Night Bus/Net Site Species Diversity Index* Source

<table>
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<tr>
<th>Site</th>
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<td>9.6</td>
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<td>1.3</td>
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<td>4.0</td>
</tr>
</tbody>
</table>

* S/D = 0.75 (MacArthur 1972)

Hoary bat.—This summer woodland resident is not con sidered a rare or uncommon species in Pennsylvania (Rich mond and Rosland 1949; Rosland 1951; Doutt et al. 1977; Merritt 1987), or elsewhere throughout its very wide geographic distribution (Whittaker and Hamilton 1998). Only four individuals captured at two of the seven different sampling areas in 1977. (Ohio, (Bruck and Finney 1987), and Indiana (Whittaker 1995; Bruck and Whittaker 2004). Insects eaten often include forest pests such as the Asiatic oak weevils (Cyrtopertha cuneata) and agricultural pests such as the spotted cucumber beetles (Diabrotica undecimpunctata) (Whittaker 1995; Bruck and Whittaker 2004).

Northern myotis.—The northern myotis is a common species of the woodland chiropterofauna of much of eastern North America. Summer maternity colonies are usually under shrubbery bark or in cracks of trees (Lucki and Schwierjohann 2001). Although similar numbers of reproductive females were caught on Ravenna and HNF, in the present study, the catch of adult males was greater than that of reproductive females. Males (n = 130) were also more common (2.48, P = 0.000) than all females (n = 62). In some portions of its range, females are more common at higher elevations (Brock et al. 2002), and females were more common on Crone. In sum mer, disparity in numbers of adult males versus adult females for many woodland species of bats may arise because density correlates with the reproductive cycle or with rainfall in specific areas or geographic areas (Brack and Whittaker 2002; Cyn 2003). During autumn swimming, numbers of males and females may vary over time and is likely related to syn chrony of mating and timing for entering into winter hibernation (LaVal and LaVal 1980; Brock et al. 2005).

In this study, northern myotis were caught more often in early evening, late in the season, and in upland habitat. In Missouri and Indiana, the northern myotis was active throughout the night and was abundant at non-riparian sites (Brack and Whittaker 2001). Similarly, on Camp Daw son, the northern myotis was more commonly caught in the evening, and upland habitat, and capture was greatest at upland sites on HNF. Use of terrestrial-based habitat is reflected in the diet. In Missouri and Indiana, lepidopterans were most important in the diet, followed by coleopterans, trichopterans, and diplopods (Whittaker and Whittaker 2001). Spiders, probably consumed while gleaning, were the sec ond most important food in the diet on Crone, and may be taken from the ground (Kirkland 1997).

Many similarities and differences in species diversity, rel ative abundance, reproductive and relative abundance of the sexes, periods of night time and seasonal activity, and use of habitat were found when comparing this investigation to studies in other wooded areas of the eastern United States. It is apparent that much of the same things we still do not know about how these species live and interact, or about the plas ticity of their ecology across the wide ranges they inhabit.
ACKNOWLEDGMENTS
Randall Russell, Dominon Gas Transmission, Inc. (Dominion), and George Reese, GAI Consultants, Inc. provided managerial and logistical support throughout the project. Dominon funded the study. Employees of Environmental Solutions & Innovations, Inc. (ESI), most notably David Jeffcott, assisted with field studies and ESI provided financial support for manuscript preparation. I thank Dean Metter and Gary Finn for inspiration.

LITERATURE CITED


EVALUATING THE USE OF FAIRMOUNT DAM FISH PASSAGE FACILITY WITH APPLICATION TO ANADROMOUS FISH RESTORATION IN THE SCHUYLKIril RIVER, PENNSYLVANIA

JOSEPH A. PERILLO1 and LANCE H. BUTLER1

ABSTRACT

Many anadromous fish stocks throughout Atlantic slope drainages have been decimated because of the construction of dams. Prior to the creation of the Fairmount Dam in 1820, migratory species, such as American shad (Alosa sapidissima), striped bass (Morone saxatilis) and river herring (alewife, Alosa pseudoharengus and blueback herring, A. aestivalis) enjoyed unimpeded movement throughout the Schuylkill River drainage as far upstream as Pottsville, Pennsylvania (160 km). In 1979, a vertical slot fish passage facility was constructed on the west side of Fairmount Dam. However, very few anadromous species were utilizing the passage and by 1984 fish restoration activities were diverted to other drainages within the Delaware River basin. Between 2002 and 2006 the Philadelphia Water Department directed its monitoring efforts above and below the Fairmount Dam fishway. In 2004, 6,438 fish of 23 species ascended the Fairmount Dam fishway, including 91 American shad, 161 striped bass, and 2 river herring. A total of 8,017 fishes representing 25 species were counted passing through the fishway in 2005, including 43 American shad, 127 striped bass, and 5 river herring. In 2006, a total of 16,850 fishes representing 26 species were counted passing through the fishway including 345 American shad, 9 hickory shad, 61 striped bass, and 7 river herring. Electrofishing sampling results from 2004 and 2006 showed A. sapidissima, A. aestivalis and A. pseudoharengus were the dominant species below Fairmount Dam during spring, with peak assemblages contributed in 2006. The interannual trend in relative abundance of American shad below Fairmount Dam, as did overall shad passage trends in the fishway. Results also suggest that photoperiod may play a critical role in movement through the fish passage facility, although additional physiological or social signals are not ruled out at this time. With expected rehabilitation efforts on the Fairmount Dam fishway to begin in 2008, this study as well as future monitoring activities will be important components in measuring the efficacy of anadromous fish restoration activities within the Schuylkill River watershed.

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INTRODUCTION

Pennsylvania has a rich history of substantial spring runs of anadromous fishes. Nowhere was this more apparent than in the Philadelphia region, where centuries of annual American shad (Alosa sapidissima) migrations helped shape the natural, cultural and economic heritage of the area (Hallock 1894). The Schuylkill River, the largest tributary to the Delaware River, supported large numbers of American shad until the construction of dams in the early 1900’s. Historical records indicate that shad and river herring (alewife Alosa pseudoharengus and blueback herring A. aestivalis) ascended the Schuylkill River as far upstream as Pottsville (160 km), but have not done so since the Fairmount Dam was built (Mulfinger and Kaufmann 1981). The dam served as a physical barrier to migratory fishes, completely blocking upstream movement and access to critical spawning grounds. In the years to follow, even more dams were erected and unregulated industrial pollution into the Schuylkill River resulted in the demise of anadromous fishes in the Schuylkill River.

For more than 150 years, American shad appeared to have been extirpated from the Schuylkill drainage (Sykes and Lehman 1957). However, in the 1970’s, Pennsylvania Fish and Boat Commission (PFBC) biologists documented the presence of American shad in the reach of the Schuylkill River below Fairmount Dam. Subsequent surveys by PFBC revealed that river water quality and habitat in the Schuylkill River could again support a substantial population of American shad as well as other anadromous fishes, provided that fish passage was created at the Fairmount Dam (Mulfinger and Kaufmann 1981). In 1979, with funding from the City of Philadelphia, United States Fish and Wildlife Service (USFWS), and P&FBC, a vertical slot fish passage facility was constructed on the west side of Fairmount Dam. During the first few years of operation, Fairmount Dam fishway was heavily used by resident fish populations; however, very few American shad or river herring were successfully ascending the fishway (Mulfinger and Kaufmann 1981). Since none of the upstream dams were passable and few anadromous fishes were passing at Fairmount Dam, the fishway was no longer actively maintained or monitored, and by 1984 restoration efforts refocused on the Lehigh River, an upstream tributary to the Delaware River. No fish passage was conducted from 1984 to 2004, until the Philadelphia Water Department (PWD) took responsibility for maintenance and operation of the fishway and developed a digital video monitoring system to record fish passage. An underwater viewing room and window allow direct observation of fishes swimming through the fishway.

The primary means for evaluating fish passage and anadromous fish restoration efforts is recorded video of fish moving past the viewing window. The recorded video allows frame-by-frame analysis to identify and enumerate species ascending and descending the fishway. These quantitative data of diversity and abundance of fish are compared to river electrofishing data in order to determine passage utilization. Monitoring fish passage will allow us to establish the size of the American shad run and compare those numbers to the upstream passage facilities and other fishways on the Delaware River. The U.S. Fish and Wildlife Service has estimated that the Schuylkill River has adequate habitat to support 700,000 to 800,000 American shad and that 200,000 to 250,000 American shad per year may utilize Fairmount fishway during upstream migration (USFWS 1999). The only way to verify the utilization and efficiency is by video recording actual fish passage at the viewing window.

As the downstream passageway, the Fairmount Dam fishway is especially critical to the overall success of restoring migratory runs of fishes in the Schuylkill River watershed. American shad annually migrate from mixed stock assemblages in the open oceans to their natal freshwater streams and rivers to spawn (Talbot and Sykes 1958; Walburg 1960; Carascand and Leggett 1975; Cleve and Leggett 1981). Shad's fidelity to their spawning river is thought to be high, and spawning populations are genetically distinct (Bentzen et al. 1989; Nolan et al. 1991; Epifanio et al. 1995). Therefore, all planned upstream fish passage projects will be affected by the success or failure of the Fairmount Dam fishway at pass- ing migratory species during spawning runs. Moreover, suc- cessful colonization and gene flow (i.e., genetic transference) of resident species is highly contingent upon minimizing the effects of fish barriers on movement (Albanese et al. 2004). Resident fish species within the Schuylkill drainage should benefit from the enhanced potential to reach suitable spawn- ning and nursery habitat, and from a larger forage base pro- vided by juvenile anadromous species.

This study describes the temporal variation of migratory and resident fish assemblages of the tidal Schuylkill River and their utilization of the Fairmount Fishway during the spring spawning period. We report on the abundance and interannual variation of fishes in the tidal Schuylkill River during spring migration, as well as temporal variability of fish passage utilization. In order to evaluate the progression of anadromous fish restoration, we examine the relationship between relative abundance downstream of Fairmount Dam and annul fish passage counts at the fishway.

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MATERIALS AND METHODS

Site Description and History

The Schuylkill River, the largest tributary of the Delaware River Basin, is located in Southeastern Pennsylvania and is approximately 198 km in length from its headwaters in Pottsville, Schuylkill County to its confluence with the Delaware River in Philadelphia, Pennsylvania (Figure 1). Fairmount Dam is positioned 13.6 km upstream from the Delaware confluence and represents the boundary between tidal and non-tidal influences on the Schuylkill River. The Fairmount Dam Fishway is situated within the City of Philadelphia on the western bank of the Schuylkill River in Fairmount Park, Philadelphia (Figure 2).

A municipally-owned facility, the Fairmount Dam is 304.8 m in length with a crest width of 3.2 m. Completed in 1821, the Fairmount Dam provided a source of drinking water as well as a pumping system for the distribution of water throughout the city of Philadelphia. However, this structure also prevented passage of fish from 1818 until 1979. Initiated in 1977 and completed in 1979, the Fairmount Dam Fishway provided a means of upstream dispersal of resident and migratory fishes. However, due to design and maintenance limitations, the function and efficiency of the Fairmount Dam Fishway has been an area of concern among fisheries biologists. Recently, the Philadelphia Water Department and the United States Army Corps of Engineers (USACE) have partnered in the restoration effort of the fishway with construction anticipated to begin in spring 2008.

Monitoring Techniques

Tidal Fish Assessments

Temporal variation of resident and migratory fish assem- blages inhabiting the tidal portions of the Schuylkill River were assessed through standardized electrofishing tech- niques (Mohnson et al. 2002). Electrofishing surveys were conducted three to four times per month from April 1st to July 1st, between 2002 and 2006. A Smith-Root gas-powered pulser (GPP) portable electrofisher with two anode bommis and a grounded umbrella was mounted to a 17 ft aluminum flat bottom boat (model Grumman). Power to the GPP was supplied by a Honda gas generator and electric- current was regulated by a foot control switch. Due to the variable hydrologic conditions found directly below the Fairmount Dam, slight modifications in boat handling and collection techniques were applied. To ensure safe boat operation and maximize capture effi- ciency, surveys were conducted in an upstream direction at a low to medium flow. Four fixed stations between the Fairmount Dam and Spring Garden Street Bridge were standardized based on sampling time (i.e., Catch Per Unit Effort) (Figure 3).

Fish were temporarily anesthetized using 2-4 amps direct current (DC) at a frequency of 60 pulses/sec.
Fish were collected using non-conductive fiberglass nets (ca. 1/2" aperture), placed in a 380 liter aerated tank, and observed for any signs of mortality. Upon completion of a single pass, fish were identified to species, total length (cm) was measured, and fish were subsequently released downstream. Because sampling efficiency was not consistently effective for young-of-the-year (YOY) fish, all individuals less than 20 mm were not included in the sample results. Moreover, to reduce mortality, American shad (Alosa sapidissima) and hickory shad (Alosa mediocri) were minimally handled through immediate identification in the water or after netting, and placement downstream of the electrofishing boat.

**Video Monitoring**

A video monitoring program was established in 2003 to assess fish passage at the Fairmount fishway and determine temporal variability of fish assemblages inhabiting the lower Schuylkill River. Video monitoring protocols remained consistent over the three-year period and required continuous operation of the camera system (i.e., 24 h) from April 1 until July 1. The monitoring program utilized an Intelex digital video camera (San Clemente, CA) and OsirisTM surveillance recording system (Suffern, NY) software to capture images of all fishes swimming past an underwater viewing window. The network-based digital video management system contains motion detection functions which only recorded when an object passed in front of the viewing window. All fish captured on video were identified to species, time stamped (i.e., hrs, min, sec) and dispersal direction (i.e., upstream vs. downstream) was recorded.

**Results**

**Tidal Fish Assessments**

Table 1 summarizes fish collection results during electrofishing surveys from 2002 to 2006. In 2002, a total of 1728 fish representing 23 species were collected during spring sampling events (Table 2). Species diversity was greatest in 2002 ($H' = 2.58$) and a more evenly distributed fish assemblage ($H' = 0.68$) was represented when compared to all of the sampling years (i.e., 2003–2006). Gizzard shad (Dorosoma cepedianum), quillback (Carpioideus cyprinus) and common carp (Cyprinus carpio) were dominant contributors to community structure during this period (24.6%, 11.8% and 10.9% contribution, respectively). Migratory species, such as *A. sapidissima*, represented only 3.6% of the fish assemblage while striped bass (*Morone saxatilis*) contributed approximately 9.6% of the total community structure. Resident fish species (Lepomis auritus, L. gibbosus and L. macrochirus) and channel catfish (Ictalurus punctatus) were also significant contributors to fish assemblage structure below the Fairmount Dam (31% and 8.3%, respectively).

Sampling results in 2003 revealed that *D. cepedianum* and *C. cyprinus* were again significant contributors to the fish community structure (29.0% and 13.5%, respectively). However, another species (A. sapidissima, A. arielis and *A. pseudoharengus*) comprised a majority of the fish assemblage, representing 42.3% of the community structure between 5/1/03 and 7/1/03. Similarly, sampling results between 2004 and 2006 showed *A. sapidissima*, *A. arielis* and *A. pseudoharengus* were the dominant species below Fairmount Dam during spring, with peak assemblage contributions in 2006 (62.7%). The marked increase in migratory species during the five-year study, however, must not overshadow the substantial decrease in certain resident populations or the presence of invasive predatory species in the tidal portions of the Schuylkill River. During 2002, sunfish species (L. auritus, L. macrochirus, and L. gibbosus) represented 9.1% of the fish community; however, sampling results during 2003–2006 revealed a substantial decrease in the presence of all sunfish species, with only a mean percent contribution of 2.0% ± 0.1%. Moreover, electrofishing surveys in 2006 demonstrated the presence of flathead catfish (*Pseudoplatystoma olivaceum*) in tidal portion of the Schuylkill River. Although the current numbers of *P. olivaceum* may not indicate an immediate threat to resident and migratory species, their presence does warrant continued monitoring to ascertain their effects on fish community structure in the Schuylkill drainage (Brown et al. 2005).
Table 3. Fish community metrics for electrofishing surveys below Fairmount Dam during spring migration (2002-2006).

<table>
<thead>
<tr>
<th>Metrics</th>
<th>Year 2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total (N)</td>
<td>1728</td>
<td>1674</td>
<td>1764</td>
<td>2890</td>
<td>5133</td>
</tr>
<tr>
<td>Species Richness</td>
<td>23</td>
<td>21</td>
<td>24</td>
<td>28</td>
<td>34</td>
</tr>
<tr>
<td>Shannon Index (IE)</td>
<td>2.39</td>
<td>1.85</td>
<td>2.03</td>
<td>2.18</td>
<td>1.92</td>
</tr>
<tr>
<td>Evenness (E)</td>
<td>0.68</td>
<td>0.53</td>
<td>0.58</td>
<td>0.62</td>
<td>0.55</td>
</tr>
</tbody>
</table>

Video Monitoring Assessments

Table 3 summarizes the fish passage results from 2004 to 2006. In 2004, there were 6,438 fish of 23 species that ascended Fairmount fishway. Anadromous fishes utilized the fishway and accounted for 3.9% of the total spring passage through the fishway, including 91 adult, 161 striped bass, and 2 river herring. American shad were observed passing by the viewing window from April 24 to June 25; striped bass were observed from April 26 to June 30, and river herring were observed from May 2 to May 15. Whereas the presence of hatchery shad (Alosa mediocris), another anadromous species, was documented in the Schuylkill River below Fairmount Dam by electrofishing surveys, A. mediocris was not observed ascending the fishway in 2004. Channel catfish and quillback were the numerically dominant species and accounted for 56.3% of total spring fish passage. White suckers (Catostomus commersonii), common carp, and razorback shiner were also abundant in the fishway during the spring migration.

A total of 8,017 fish representing 25 species passed through the fishway in 2005, a 20% increase in fish passage by both resident and migratory species compared to 2004. Anadromous fishes accounted for 2.2% of total spring fish passage including 41 American shad, 127 striped bass, and 5 river herring. Despite the increase in total fish passage during 2005, there were decreases in numbers of two anadromous species.

Table 3. Fish passage counts by species at the Fairmount Dam Fishway, Schuylkill River, Pennsylvania, during spring monitoring. Species status codes are as follows: NA = native anadromous; NC = native catadromous; NR = native resident; IR = introduced resident; and I = introduced.

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Status</th>
<th>2004a</th>
<th>2004b</th>
<th>2005a</th>
<th>2005b</th>
<th>2006a</th>
<th>2006b</th>
</tr>
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<tbody>
<tr>
<td>Alosa mediocris</td>
<td>history shad</td>
<td>NA</td>
<td>0</td>
<td>0</td>
<td>9</td>
<td>2</td>
<td>0</td>
<td>2</td>
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<tr>
<td>Alosa sapidus</td>
<td>American shad</td>
<td>NC</td>
<td>91</td>
<td>41</td>
<td>345</td>
<td>36</td>
<td>12</td>
<td>34</td>
</tr>
<tr>
<td>American shad</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amia calva</td>
<td>white catfish</td>
<td>IR</td>
<td>6</td>
<td>1</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Amia spp.</td>
<td>bulbhead catfish</td>
<td>NR</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Amphibolops raperi</td>
<td>rock bass</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anguilla rostrata</td>
<td>American eel</td>
<td>NC</td>
<td>32</td>
<td>70</td>
<td>34</td>
<td>36</td>
<td>12</td>
<td>34</td>
</tr>
<tr>
<td>Anchoa transitor</td>
<td>white sucker</td>
<td>NR</td>
<td>731</td>
<td>1767</td>
<td>2888</td>
<td>2989</td>
<td>1229</td>
<td>542</td>
</tr>
<tr>
<td>Cottus carpio</td>
<td>quillback</td>
<td>NR</td>
<td>1807</td>
<td>2962</td>
<td>2631</td>
<td>2962</td>
<td>1384</td>
<td>651</td>
</tr>
<tr>
<td>Cottus pharaonis</td>
<td>gizzard shad</td>
<td>IR</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Cottus carpio</td>
<td>striped shad</td>
<td>IR</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cottus carpio</td>
<td>rainbow shad</td>
<td>IR</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Cottus carpio</td>
<td>bluegill shad</td>
<td>IR</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cottus carpio</td>
<td>unknown sunfish</td>
<td>IR</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cottus carpio</td>
<td>smallmouth bass</td>
<td>IR</td>
<td>143</td>
<td>124</td>
<td>1225</td>
<td>1225</td>
<td>52</td>
<td>1225</td>
</tr>
<tr>
<td>Cottus carpio</td>
<td>largemouth bass</td>
<td>IR</td>
<td>10</td>
<td>42</td>
<td>112</td>
<td>112</td>
<td>10</td>
<td>112</td>
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<tr>
<td>Morone americana</td>
<td>white perch</td>
<td>NR</td>
<td>55</td>
<td>105</td>
<td>112</td>
<td>112</td>
<td>55</td>
<td>112</td>
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<tr>
<td>Morone saxatilis</td>
<td>hybrid shad</td>
<td>IR</td>
<td>20</td>
<td>15</td>
<td>48</td>
<td>48</td>
<td>20</td>
<td>48</td>
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<tr>
<td>Morone saxatilis</td>
<td>hybrid shad</td>
<td>IR</td>
<td>20</td>
<td>15</td>
<td>48</td>
<td>48</td>
<td>20</td>
<td>48</td>
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<tr>
<td>Osteochilus mykiss</td>
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<td>7</td>
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<td>13</td>
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<tr>
<td>Pylodictus olivaris</td>
<td>fishhead catfish</td>
<td>IR</td>
<td>68</td>
<td>43</td>
<td>466</td>
<td>466</td>
<td>68</td>
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<td>IR</td>
<td>2</td>
<td>5</td>
<td>9</td>
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<td>9</td>
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<td>hybrid trout</td>
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<td>4</td>
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<td>5</td>
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<td>5</td>
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<td>rainbow trout</td>
<td>IR</td>
<td>57</td>
<td>33</td>
<td>64</td>
<td>64</td>
<td>57</td>
<td>64</td>
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<td>unknown catfish</td>
<td>IR</td>
<td>12</td>
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<td>0</td>
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<td>unknown sunfish</td>
<td>IR</td>
<td>3</td>
<td>7</td>
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<td>0</td>
<td>3</td>
<td>7</td>
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<td>Schizothorax oregonensis</td>
<td>unknown shad</td>
<td>IR</td>
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<td>Schizothorax oregonensis</td>
<td>unknown trout</td>
<td>IR</td>
<td>7</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>1</td>
</tr>
</tbody>
</table>

TOTAL: 6438  8017  16850

*Power output to the viewing room and video monitoring system resulted in 362 hours of video data.
*Power output to the viewing room and video monitoring system resulted in 321 hours of video data.
*Power output to the viewing room and video monitoring system resulted in 168 hours of video data.
(A. sapidissima and M. saxatilis). The increase in total fish passage in 2005 was mainly from increased abundance of C. commersonii, C. cyprinus, C. carpio, and Morone americana.

Through video surveillance in 2005, American shad were observed passing by the viewing window from April 18 to June 28; striped bass were documented from May 11 to June 30; and river herring were observed from April 8 to June 18. River herring were the only anadromous fishes to increase in abundance from 2004 to 2005. Five resident species (C. cyprinus, C. commersonii, D. cepedianus, L. punctatus, and C. carpio) constituted 90.1% of fish passage during the spring migration. Moreover, there were several species documented in 2005 that were not represented in 2004, such as rock bass (Ambloplites rupestris), salem’s shiner (Cyprinella salemensis), and pumpkinseed sunfish (L. gibbosus).

In 2006, a total of 16,850 fish representing 26 species were counted passing through the fishway, a two-fold increase in fish passage numbers when compared to 2005. Also, American shad passage increased 279.1% from 2004 to 2006 and 741.5% from 2005 to 2006. Anadromous fishes accounted for 2.5% of total spring fish passage including 345 American shad, 9 hickory shad, 61 striped bass, and 7 river herring. A. sapidissima were observed passing by the viewing window from April 11 to June 6; M. saxatilis were documented from May 14 to June 24; A. smaragdina and A. pseudoharengus were counted from May 2 to June 20. In addition, 9 hickory shad passed through Fairmount fishway during a three day period (i.e., May 3 to May 6). This is the first confirmed passage of hickory shad, an endangered species in Pennsylvania, above Fairmount Dam in recorded history for the Schuylkill River. There is no reference to hickory shad in early historical fisheries accounts for the Delaware Estuary in Pennsylvania (Majumdar et al. 1986).

Similar to the previous years, C. commersonii, C. cyprinus, C. carpio, D. cepedianus, and L. punctatus were extremely abundant in the fishway, accounting for 83.4% of total fish passage in 2006. New records of fish passage were also documented for hickory shad and bullhead catfish (Ameiurus nr); while previous recordings of rock bass and salem’s shiner (C. australis) were not observed in 2006. During the 2004–2006 migratory periods, channel catfish (n = 6,900) and quillback (n = 6,480) were the numerically dominant species. White sucker, common carp, and gizzard shad were also relatively abundant compared to other species (Table 2). American shad, smallmouth bass (Micropterus dolomieui), flathead catfish, bluegill (L. macrochirus), and gizzard shad numbers increased dramatically from 2004 to 2006, while most species displayed relatively minor interannual fluctuations. It should be noted that redbreast sunfish (Lepomis auritus) and striped bass numbers decreased during the study period.

Diurnal Passage

Based on diurnal passage studies of anadromous species from 2004–2006 (Figures 4 to 7), peak passage generally occurred during periods 4 and 5, which corresponds to late morning through early evening. American shad passage was documented during each diurnal period; however, peak passage occurred from 16:00 hrs to 19:59 hrs, with a secondary peak from 12:00 hrs to 15:59 hrs (Figure 4). Hickory shad only passed during periods 3, 5, and 6, with peak passage also from 16:00 hrs to 19:59 hrs (Figure 5). Striped bass displayed a complex pattern passage, utilizing the fishway at all hours of the day, but mostly passing during the daylight hours. Peak passage for M. saxatilis occurred from 16:00 hrs to 19:59 hrs (Figure 6). River herring preferred utilizing the fishway during low-light hours more than any other anadromous species, with a majority of passage occurring during diurnal periods 1 and 5 (Figure 7).

Catch Per Unit Effort (CPUE)

Relative abundance of anadromous species for the tidal Schuylkill River below Fairmount Dam was collected from 2002 to 2006 (Figure 8). Catch per unit effort (CPUE) was used as an index of population (i.e., relative abundance) and expressed in the number of fish collected per minute of elec-
native anadromous, catadromous, and resident fishes, as well as introduced species, several of which have become estab-
lished. More importantly, video surveillance has revealed that both resident and migratory species readily ascend the
Fairmount Dam fishway. Weaver et al. (2003) showed simi-
lar results in their study of the James River, implying that resi-
dent species ascending the fishway may result in addi-
tional ecological benefits to the river and its tributaries.
During our three-year study, a total of twenty-six species of
fish, as well as several hybrid species, were documented
using the fishway during spring migrations. Anadromous
fishes, such as American shad, hickory shad, striped bass,
and river herring, frequently utilized the fishway for passage
above the dam, and the presence of juvenile alewife
upstream of the fishway in 2005-2006 suggests that quality
spawning and nursery habitats still exist above Fairmount
Dam. Moreover, fish passage counts for adult American shad
show a discernible increase during the three-year period and
although the numbers are significantly lower than historical
records, fish surveys below Fairmount Dam indicate increas-
ing trends in fish density during spring migrations.
Analysis of diurnal passage patterns revealed that the
majority of anadromous species utilized the fishway during
daylight periods (i.e., 12:00 and 19:59 hours), with some
species specific variation. These findings corroborate with
those of Weaver et al. (2003) at a James River vertical slot
fishway in Virginia and Arnold (2000) at a Lehigh River
vertical slot fishways in Pennsylvania. Our findings suggest
that photoperiod may be one of the primary factors trigger-
ing upstream dispersal of migratory fish through the Fair-
mount Dam fishway; however, additional studies on physio-
chemical variables (e.g., temperature) and biotic interac-
tions (e.g., predation) may need to be addressed before a
definitive conclusion can be made.

This study represents the first detailed examination of fish
community structure and fish ladder utilization by resident
and anadromous species in the lower Schuykill River Drainage in approximately twenty years. More specifically,
Mullfinger and Kaufmann (1981) showed that annual Ameri-
can shad counts did not exceed twenty-two (n=22), while
the current study documented a maximum of 345 American
shad in 2006. Moreover, only one striped bass was observed
passing through the fishway from 1979 to 1984; whereas, 349
striped bass passed through the fishway in 2006. During this peri-
od, significant improvements in water quality have been
made, while ecosystem-based restoration strategies, includ-
ing dam removals and fish passage restorations, within the
Schuykill River basin have only recently been addressed.
Currently, the Philadelphia Water Department and the Unit-
ed States Army Corps of Engineers have joined resources to
restore the Fairmount Dam fishway, with construction efforts
planned to commence in 2008. The Pennsylvania Fish and
Boat Commission have also begun to refocus their efforts of
American shad restoration by strengthening their shad fry
stocking program in the Schuykill River. In addition, there
are several proposed plans for either fish passage facilities or
dam removals for the remaining barriers on the Schuykill River, with an ultimate goal of providing kilometers of
upstream habitat for resident and migratory species.

While the current restoration strategies along the Schuykill River continuum may have a synergetic effect on the
success of resident and migratory fishes, it is imperative
that emphasis be placed on the largest, and perhaps, most
important fishway. The fish passage facility at Fairmount
Dam must be redesigned and built to optimize fish passage,
otherwise precious resources and current restocking pro-
grams will have been wasted (Weaver et al., 2003). Prelimi-
ary results from our study indicate that proper operation,
maintenance, and monitoring of the fishway may have a
critical role in reestablishing anadromous fish populations
throughout the Schuykill River watershed. Although the total
number of anadromous fish passed between 2000-2006 is relatively low, this information will serve as a
baseline for pre-restoration efforts and will allow scienc-
ists to gauge the success of this fishway and future ecosys-
tem-based activities within the Schuykill River drainage.

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IDENTIFICATION OF STAPHYLOCOCCUS SPP. AND AEROBIC GRAM-NEGATIVE BACTERIA FROM THE CLOACAE OF MIGRATORY SHOREBIRDS (FAMILY SCOLOPACIDAE) FROM DELAWARE BAY, NEW JERSEY

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Fish and Wildlife Microbiology Laboratory, Department of Biological Sciences, East Stroudsburg University, East Stroudsburg, PA 18301

ABSTRACT

A survey was conducted of the bacterial flora of migratory shorebirds from Delaware Bay, NJ. Fifty-four birds were sampled on 18 May, 2004 at Fortescue Beach, NJ and 37 birds were sampled on 20 May, 2004 at Reed's Beach, NJ. The sampled shore birds included 38 red knots (Calidris canutus), 16 dunlins (Calidris alpina), 9 ruddy turnstones (Arenaria interpres), 18 semipalmated sandpipers (Calidris pusilla), and 10 sandpipers (Calidris alba). Twenty-four different bacterial species were identified, 15 were identified to species and 9 were identified to genus. Organisms isolated included Vibrio fluvialis, Staphylococcus aureus, Staphylococcus warneri, Staphylococcus sciuri, Staphylococcus xylosus, S. hominis, Micrococcus spp., Escherichia coli, Enterobacter sakazakii, Enterobacter cloacae, Serratia liquefaciens, and Pseudomonas spp. A total of 19 different bacteria were isolated from red knots, 11 from dunlins, 7 from ruddy turnstones, 10 from semipalmated sandpipers, and 6 from sandpipers. [J PA Acad Sci 81(1): 34–37, 2009]

INTRODUCTION

The Delaware Bay is one of the largest gatherings of migratory shorebirds on the East Coast and is the second largest gathering in North America (Clark et al., 1993). The Delaware Bay stopover is an important staging area for shorebirds migrating from wintering sites in and around South America to Arctic and sub-arctic breeding areas (Bot-tet al., 1994). Delaware Bay is located along the east coast, at the southern border of New Jersey and the northern border of Delaware (38°47'N to 39°20'N and 74°50'W to 75°30'W) (Clark et al. 1993). The migrating shorebirds arrive at the Delaware Bay from mid-May through the beginning of June and spend 10–14 days feeding mostly on horseshoe crab (Limulus polyphemus) eggs (Myers, 1983; Esterichia coli (1%), The following bacterial species were isolated only once: Alcaligenes spp., Citrobacter freundii, Enterobacter sakazakii, Klebsiella spp., Salmonella spp., Serratia spp., Staphylococcus epidermidis, Staphylococcus hominis, and Pseudomonas spp.

Enterobacter cloacae, fluorescent Pseudomonas spp., Pseudomonas spp., Micrococcus spp., and S. aureus were isolated from all five migratory bird species. The remaining bacterial species were isolated from one or more of the five bird species (Table 1). Escherichia coli was the only species isolated from the red knots and the dunlins (Table 1). Staphylococcus sciuri was isolated from all bird species except the sandpipers (Table 1). A total of 19 different bacteria were isolated from red knots, 11 from dunlins, 7 from ruddy turnstones, 10 from semipalmated sandpipers, and 6 from sandpipers.

All of the shorebirds sampled in this study appeared healthy at the time of collection. The shorebirds at the Delaware Bay stopover had already traveled on average 5,000 miles. The bacterial species identified during this study may represent some of the bacterial flora commonly occurring in the intestines of birds of the Family Scolopacidae. Many of the bacterial species isolated during this study have been isolated from other bird species. Seagulls have been shown to act as carriers of Salmonella spp. (Frenlin, 1981; Quassay and Messier, 1992). Bacteria isolated from the gastrointestinal tract of other wild bird species included Escherichia coli, Pseudomonas spp. and Staphylococcus Table 1: Staphylococcus spp. and aerobic Gram-negative bacteria identified from cloacal swabs of migratory shorebirds (Family Scolopacidae) from Fortescue Beach and Reed's Beach along Delaware Bay, NJ on May 18 and 20, 2004. The numbers in parentheses indicate the percentage of isolates identified.

<table>
<thead>
<tr>
<th>Bacterial Species</th>
<th>Red Knot (N = 38)</th>
<th>Dunlin (N = 16)</th>
<th>Ruddy Turnstone (N = 9)</th>
<th>Semipalmated Sandpiper (N = 18)</th>
<th>Sandpiper (N = 10)</th>
<th>Total (N = 93)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcaligenes spp.</td>
<td>1 (3)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1 (5)</td>
<td>1 (3)</td>
</tr>
<tr>
<td>Chromobacterium spp.</td>
<td>1 (3)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1 (5)</td>
<td>1 (3)</td>
</tr>
<tr>
<td>Citrobacter freundii</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Enterobacter cloacae</td>
<td>2 (5)</td>
<td>0</td>
<td>0</td>
<td>1 (6)</td>
<td>2 (10)</td>
<td>6 (17)</td>
</tr>
<tr>
<td>Enterobacter sakazakii</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Escherichia coli</td>
<td>1 (3)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1 (5)</td>
<td>1 (3)</td>
</tr>
<tr>
<td>Flavobacterium spp.</td>
<td>1 (3)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1 (5)</td>
<td>1 (3)</td>
</tr>
<tr>
<td>Pseudomonas aeruginosa</td>
<td>0</td>
<td>1 (6)</td>
<td>0</td>
<td>0</td>
<td>1 (5)</td>
<td>1 (3)</td>
</tr>
<tr>
<td>Pseudomonas latipes</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pseudomonas putrefaciens</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Serratia liquefaciens</td>
<td>1 (3)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1 (5)</td>
<td>1 (3)</td>
</tr>
<tr>
<td>Serratia sp.</td>
<td>1 (3)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1 (5)</td>
<td>1 (3)</td>
</tr>
<tr>
<td>Staphylococcus aureus</td>
<td>3 (8)</td>
<td>0</td>
<td>2 (22)</td>
<td>1 (6)</td>
<td>5 (50)</td>
<td>12 (33)</td>
</tr>
<tr>
<td>Staphylococcus epidermidis</td>
<td>1 (3)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1 (5)</td>
<td>1 (3)</td>
</tr>
<tr>
<td>Staphylococcus hominis</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1 (6)</td>
<td>2 (22)</td>
<td>3 (10)</td>
</tr>
<tr>
<td>Staphylococcus sciuri</td>
<td>5 (13)</td>
<td>0</td>
<td>1 (11)</td>
<td>1 (6)</td>
<td>3 (30)</td>
<td>11 (32)</td>
</tr>
<tr>
<td>Staphylococcus warneri</td>
<td>4 (10)</td>
<td>0</td>
<td>1 (11)</td>
<td>1 (6)</td>
<td>6 (50)</td>
<td>16 (47)</td>
</tr>
<tr>
<td>Staphylococcus xylosus</td>
<td>0</td>
<td>0</td>
<td>2 (22)</td>
<td>0</td>
<td>0</td>
<td>2 (6)</td>
</tr>
</tbody>
</table>

METHODS

Shorebirds were sampled on 18 May, 2004 at Fortescue Beach, NJ (39°14'16.79"N, 75°10'20.26"W) and 20 May, 2004 at Reed’s Beach, NJ (39° 7’11.5"N, 74°53’29.44"W). The birds were captured by rocket net by personnel from the New Jersey Division of Fish and Wildlife Endangered and Nongame Species Program. Each bird was weighed and banded. The cloaca of the birds were sampled using a sterile swab (Fisher Scientific, USA). The swabs were placed into vials of tryptic soy broth (TSB). The vials of TSB were transported back to the laboratory at 4°C to reduce bacterial growth. The bird species sampled were red knots (Calidris canutus), dunlins (Calidris alpina), ruddy turnstones (Arenaria interpres), semipalmated sandpipers (Calidris pusilla), and sanderlings (Calidris alba).


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resistance and conjunctivae R plasmids in Escherichia coli
MICROANATOMY OF GASTRO-INTESTINAL TRACT OF MASTACEMBUS ARMATUS (LACEPEDE): A SCANNING ELECTRON MICROSCOPY STUDY

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ABSTRACT

Mastacembelus armatus (Lacepede) have short and nearly straight gastro-intestinal tracts with loops at both ends of the stomach. It begins with the mouth and ends with the anus. The topological specialization of the intestinal surface of the stomach, intestine and rectum, including the buccopharynx has been investigated using a scanning electron microscope. It has been found that the floor of the buccopharynx has few taste buds and it mainly serves as a passage of respiratory water current. The main feature of the oesophagus is the presence of microridges and test buds. The stomach is provided with numerous folds to increase digestive surface area and is differentiated clearly into anterior cardiac and posterior pyloric stomach. The intestine is provided with zig-zag folds and maximum secretion of mucin. The internal surface of the rectum is made up of numerous irregular loop-like mucosal folds and is differentiated into anterior and posterior parts.


INTRODUCTION

Morphology, histology and histochemistry of the alimentary canals of teleostean fishes have received considerable attention (Chakrabarti and Sinha, 1957; Jaish, 1968; Srivastava, 1968; Sinha, 1981; Moitra, 1984; Kumar & Bohra, 2003). However, there is only limited information available on the topological characteristics of the intestinal surface of the gastro-intestinal tracts of teleosts (Eisnar and Scocone, 1980; Sinha, 1981; Moitra, 1984; Sinha and Chakrabarti, 1986a and 1986b; Choudhary, 1992).

RESULTS

M. armatus is a carnivorous fish with a small and straight gut with single loops at both ends of the stomach. It begins at the mouth and ends at the anus (Figure 1). It is differentiated into the following distinct regions with their unique topological features of internal surface.

1. Buccopharynx

The surface of the buccopharynx is rough and consists of vascular and non-vascular areas. Few mucin droplets can also be seen scattered variably (Figure 2a).

2. Oesophagus

The entire inner surface of the oesophagus is arranged into folds. The folds are vertically arranged. Higher magnification of these folds revealed their surface to be sculptured by the microridged individual epithelial cells. Many mucous gland openings are detected (Figures 2b & 3a).

3. Stomach

The stomach consists of a large longitudinal fold along with small vertical interconnecting folds. These folds are covered with several hundreds of epithelial cell units and join one another encircling the pits of the gastric glands. The shapes and sizes of the folds and the pits of these glands are irregular. The epithelial cells are continued inside the pits. Mucin droplets are also observed here and seen sporadically (Figure 3b).

4. Intestine

The inner wall of the intestine exhibits zig-zag mucosal folds which may be recognized as primary mucosal folds. The adjacent primary mucosal folds roughly run parallel with each other throughout the entire length, thus forming a single continuous, but relatively shallow cavity. The primary mucosal folds are provided with few secondary ones. Various mucous gland openings are also observed infrequently. The surface is covered by mucus in such a way that it is difficult to recognize the epithelial cell boundaries (Figure 4a).

5. Rectum

The surface of the rectum exhibits highly irregular mucosal folds enclosing shallow cavities. In high magnification it was observed that the mucosal folds of the rectum were provided with ridges and numerous minute circular openings. The secreted mucin covers the circular openings/pores. The circular openings present in the rectum were larger in diameter, yet secreted mucin droplets were left to cover less openings. Microridges were of the same pattern as observed in oesophagus (Figures 4b, 5a & 5b).

DISCUSSION

M. armatus is a carnivorous fish for which the value of the Relative Length of Gut (RLG) is less than one. Its alimentary canal shows various degrees of differentiation of its internal mucosal topography. The internal mucosal architectural pattern was examined using a scanning electron microscope. It was revealed that structurally, the gastro-intestinal tract could be divided into buccopharynx, oesophagus, stomach, intestine and rectum.
The floor of the buccopharynx has numerous respiratory islets but few taste buds. The paucity of taste buds in the buccopharynx was observed earlier by Moitra (1984), and Choudhury (1992) in the buccopharynces of Clarias batrachus (Linn) and Heteropneustes fossilis (Bloch). The buccopharynx seems to be a passage of respiratory water current, while the presence of taste buds is evidently related to the selection of food. The mucus covering the surface aids the passage of food, and the microtubed surface of the buccopharynx epithelium helps in fixing the mucus. Under low magnifications, oesophageal surface also shows microtubed cells. In some instances, the mucus glands openings are seen to be covered by the mucus.

The entire stomach is arranged into folds, which increases the digestive surface area. The mucosal folds of the stomach are vertically arranged and covered with numerous columnar epithelial cells. These folds join one another enclosing the gastric gland pits. Scattered mucous droplets are also seen adhering to certain epithelial cells. Similar observations have been made by Sis et al. (1979), Ezreasor and Strooki (1980), and Choudhary (1992) in teleosts in SEM studies. However, it has been found that the shapes and sizes of the folds and pits are dissimilar in different species.

The mucosal folds of the intestine are interconnected with each other, forming a complex zig-zag pattern. The columnar epithelial cells exhibit shallow irregular depressions and mucin droplets of varying shapes and sizes.

Highly irregular mucosal folds in the forms of loops were also observed in the rectum.

**LITERATURE CITED**


RESEARCH NOTE

EXTENSIONS OF THE KNOWN RANGES OF PERCINA SHUMARDII GIRARD AND THREE SPECIES OF ETHEOSTOMA (SUBGENUS NOTHONOTUS) IN PENNSYLVANIA

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ABSTRACT

We used Missouri benthic trawls to sample benthic fish assemblages of the Ohio River within Pennsylvania during the summer and autumn of 2007. As part of our survey, we established range extensions for four species of darters (Percidae: Etheostomini). These included the River Darter, Percina shumardi Girard, which is a new species record for Pennsylvania, although it is common in lower reaches of the Ohio River. We also extended the ranges of Bluebreast Darter, Etheostoma camurum (Cope), Spotted Darter, Etheostoma maculatum Kirkland, and Tippecanoe Darter, Etheostoma tippecanoe Jordan and Evermann, into the Ohio River. These latter three species are classified as threatened within Pennsylvania. The expansion of the known ranges of these fishes may be due to water quality improvement in the Ohio River, or may be the result of more efficient sampling techniques. Further sampling is warranted to elucidate their full ranges within Pennsylvania.

INTRODUCTION

Over the past several years while conducting mussel surveys, we have noted the abundance of many species of darters (Percidae: Etheostomini) in the deep pools and runs of large rivers. These habitats are difficult to sample for small fishes; thus they have been underrepresented in ichthyological surveys. The development of the Missouri benthic trawl (Herzog et al. 2005) for sampling small benthic fishes has greatly improved the effectiveness of our sampling large riverine habitats; hence, our knowledge of the distribution and abundance of these species has increased. As a result of utilizing these sampling techniques, we extended the known ranges of the River Darter, Percina shumardi Girard, and three species of Etusomma (subgenus Notohnotus) in Pennsylvania.

METHODS AND MATERIALS

We sampled the Ohio River in Pennsylvania at regular 1.0 km intervals from its formation at the confluence of the Allegheny and Monongahela rivers in Pittsburgh to the Ohio and West Virginia border (Fig. 1) in August 2007. We sampled the tailwaters of the Montgomery Dam (New Cumberland Dam) and the Dashields Dam (Montgomery Pool) in October 2007. Sampling was conducted using a Missouri benthic trawl according to the sampling protocols established by Herzog et al. (2005). Trawls were conducted in the central channel as well as near-shore, at depths ranging between 1.5-6.7 m. All fishes were identified in the field, with voucher specimens retained for laboratory verification.

RESULTS AND DISCUSSION

We captured a total of 33 River Darters, Percina shumardi (Fig. 2), from the Ohio River. We collected four individuals in the New Cumberland Pool of the Ohio River; and two individuals each at two sites located approximately 7 km and 11 km upstream from the Ohio/West Virginia border, respectively (PSU 4477, Fig. 1). Further targeted sampling revealed that their range within Pennsylvania extends at least 34 km upstream on the Ohio River to the Dashields Dam (PSU 4459, 4460, 4476).

The River Darter is distributed throughout the Mississippian River drainage, and is locally abundant in the Ohio River into West Virginia and Ohio, as well as being the most common darter collected from the Mississippi River (Kushn and Barbout 1963, Page 1983). While River Darters have never been collected from Pennsylvania prior to this study, Cooper (1983) suggested that they may be a future migrant into Pennsylvania as water quality improved. Although River Darters have been thought to be invertebrate-specialists, Cooper (1981, Page 1983) has determined that they may also specialise in feeding on snails, similar to other species of Percina, subgenus Imnotoma (Haag and Warren Jr. 2006).

River Darter habitat consists primarily of large rivers with gravel/cobble/boulder substrates and with moderate to fast currents (Scott and Crossman 1973, Trautman 1981, Cooper 1983, Page 1983), with younger individuals inhabiting shallower water. Specimens have been collected, however, from areas which are too turbid for many other darter species (Scott and Crossman 1973, Trautman 1981, Kushn and Barbout 1983), and also from streams (Haag and Warren Jr. 2006); thus, these range extensions for P. shumardi within Pennsylvania may underestimate their true distribution within the state.

We collected three Bluebreast Darters, Etheostoma camurum (Cope), from Montgomery Dam tailwaters (New Cumberland Pool, PSU 4459). Seven Bluebreast Darters, five Spotted Darters, Etheostoma maculatum Kirkland, and one Tippecanoe Darter, Etheostoma tippecanoe Jordan and Evermann, were collected from the Dashields Dam tailwaters (Montgomery Pool, PSU 4476). These data are located approximately 13 km and 34 km from the Ohio/West Virginia border, respectively (Fig. 1).
These three species are presently classified as threatened within Pennsylvania by the Pennsylvania Fish and Boat Commission (2007). The Tippecanoe Darter has heretofore been reported only from the Allegheny River system. The Bluebeard Darter and Spotted Darter were collected from the Allegheny and Mahoning rivers, but have been extirpated from the latter (Bean 1892, Cooper 1983). The closest records downstream of the state line for the Bluebeard Darter and Tippecanoe Darter are from the lower Muskingum River, but they probably occurred in the unimproved Ohio River as well (Trautman 1981). The nearest downstream records of the Spotted Darter include the middle sections of the Elk River in West Virginia (Stauffer Jr. et al. 1995) and Muskingum and Scioto rivers in Ohio (Trautman 1981), but there are none from the mainstem Ohio River. Water quality in the Ohio River has been improving over the last 50 years, with marked improvement since the Clean Water Act was implemented in 1972, and is closely correlated with marked improvements in fish diversity and assemblages from 1957–2001 (Thomas et al. 2005). Their records, facilitated by the use of benthic trawls as a novel sampling gear, therefore most likely represent an expansion of the Allegheny River populations of all three species as a result of improved water quality. Additional sampling is warranted to elucidate the full range of these species throughout the Ohio River drainage in Pennsylvania, including both the Allegheny and Monongahela rivers. It is likely that further sampling using benthi c trawls will yield more new species records for Pennsylvania and document additional range extensions.

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3. Title. Brief and to the point. It should inform the reader of the subject of the paper.
4. Byline. Include the author's name, name of institution, department, address and e-mail address.
5. Abstract. A clear and concise paragraph summarizing the paper. Normally, it will be in lieu of a formal summary section.
6. Introduction. The introduction should be concise and offer only that information necessary to orient the reader to the purpose and scope of the paper. It should state the reasons for the work and cite only published literature relevant to the subject.
7. Materials and Methods. Describe materials, methods, and equip-
ment. Avoid repeating previously published details; needless modifi-
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